New Scientist

WEEKLY 28 September 2024

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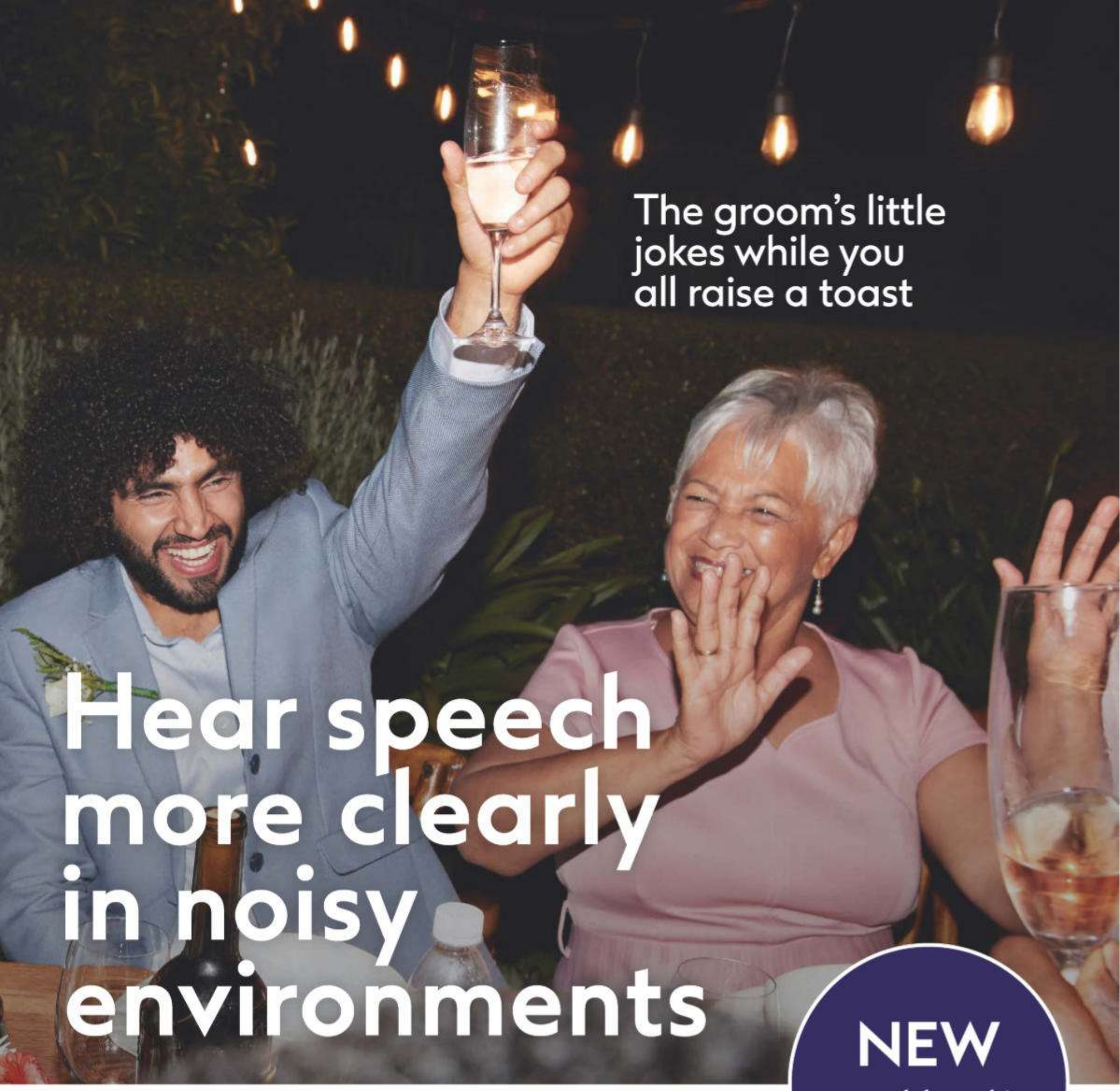

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There are just two weeks to go until our flagship science show. Visit our website to explore the programme of talks, speakers and experiences

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NS Live

Laws of connection

Strong social ties bring joy, bolster our health and increase our longevity. But finding and maintaining healthy relationships can be hard. Hear science writer David Robson on 13 October at New Scientist Live, online or in person at London's ExCeL Centre, as he examines the psychological barriers that prevent us from connecting to others, and how to overcome them.

newscientist.com/nslmag

Tour

The science history and culture of Vienna

Vienna has long been one of Europe's most important cultural and academic melting pots. Join psychologist Dany Nobus as you unravel the mind of Sigmund Freud and learn about the many other influential thinkers, artists and politicians who have called this city home over the past several centuries. The five-day tour starts on 8 December 2025 and costs £2286.

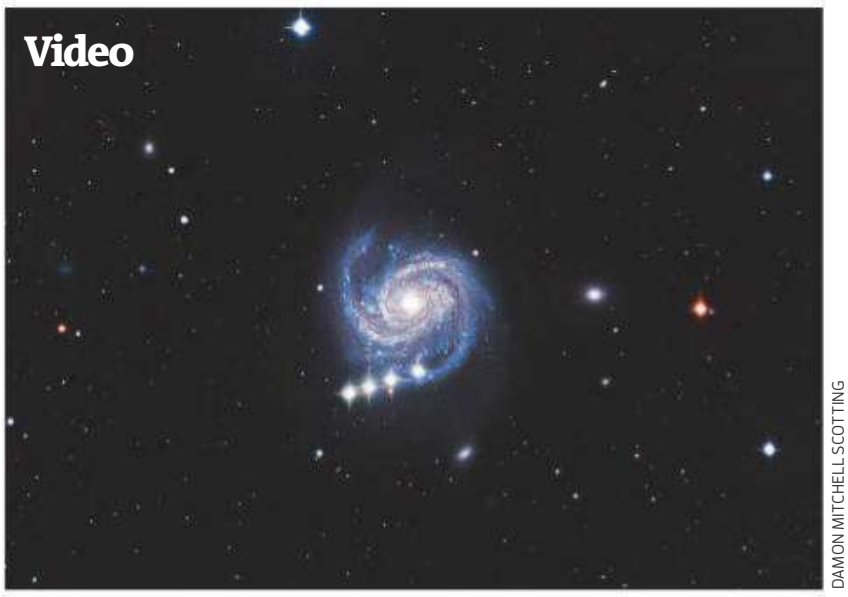
newscientist.com/tours

Podcast

Weekly

The team hears how dark matter in the early universe may be why we have supermassive black holes today. Learn about a tiny lizard that we have no choice but to love and a particle that travelled in negative time without breaking the laws of physics. In other news, researchers are beginning to rethink the role of loneliness in our health, and Earth possibly once had its own ring of debris.

newscientist.com/nspod



DAMON MITCHELL SCOTTING

Astro competition This Blow Dryer galaxy image is on show in London

DOUNIA LG/SHUTTERSTOCK

Fantastic cacti Getting to the root of this eclectic plant family

Video

Galactic snaps

An exhibition of the winners of Astronomy Photographer of the Year – plus some of the competition's shortlisted entries – is now on at the National Maritime Museum in London. Ed Bloomer, senior astronomy manager at Royal Museums Greenwich, takes us on a tour of his favourites. "There's a real blast of awe and wonder," he says.

youtube.com/newscientist

Newsletter

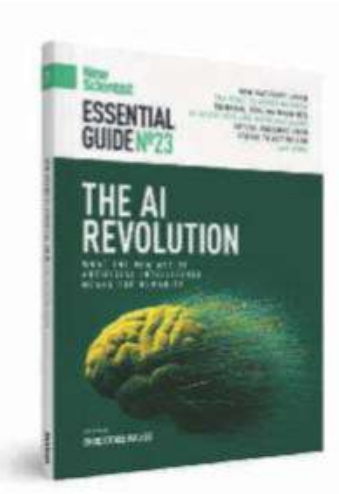
Wild Wild Life

Cacti are one of the world's most beguiling plant families, but how and why they evolved their many diverse shapes and sizes has been a mystery. Now, researchers are untangling the ancient history of the Cactaceae, revealing the forces that shaped these spiky plants and prompting concern for their future.

newscientist.com/wild-wild-life

Podcast

"It's time to re-evaluate a loneliness-first approach to improving health"



Essential guide

Tools such as ChatGPT have put artificial intelligence on front pages around the world. So why has AI leapt forwards so suddenly? How can generative AI tools help you? And will this tech lead to human extinction? Get the lowdown on all this and more in our new *Essential Guide*, on sale now.

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Out of options

If we want to preserve the remaining ice at our poles, we must take drastic action now

THE first explorers known to have reached the North Pole spent weeks dragging their sleds across the rough pack ice. Now, people can travel most of the way there from the comfort of a cruise ship, their passage eased by the catastrophic melting of ice caused by climate change.

The Arctic is shedding ice at a rate of 12 per cent per decade and is set to be ice-free in the summer by the 2030s – regardless of how fast we cut emissions from now on. Meanwhile, in Antarctica, the vast Thwaites glacier is cracking under the pressure of global warming (see page 13), and Antarctic sea ice has been tracking at record lows in 2024 for the second year running.

We must cut emissions, and fast, but that alone won't be enough to stop the runaway melt in the Arctic. To buy us time and to buttress this delicate habitat from a warming world, geoengineering is probably our only hope.

One solution comes from start-up Real Ice, which plans to use seawater to thicken the Arctic's ice (see page 10). It is controversial. Geoengineering of this sort, opponents argue, risks distracting humanity from the gargantuan task of cutting emissions.

> "Of all our geoengineering options, refreezing the poles is perhaps the most benign"

Yet there are good reasons to push ahead. Alongside the spectacular wildlife and rich cultural heritage there, the polar regions do the world a huge favour. Their white caps reflect solar radiation back into space, helping to keep Earth's climate cool. The loss of Arctic sea ice also triggers a whole host of other feedbacks that would amplify climate change and play havoc with weather systems around the world.

Of all our geoengineering options, refreezing the poles is perhaps the most benign. There are, of course, risks. Thorough impact assessments will be vital to minimise any harmful effects on wildlife, local communities or wider Earth systems. But without action, the ice will disappear, destabilising the global climate.

Cuts to greenhouse gas emissions should have started decades ago. The delay has left us with no time to be squeamish about geoengineering. ▮

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CONTACT US
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General & media enquiries
UK 9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066
US 600 Fifth Avenue, 7th Floor, NY 10020

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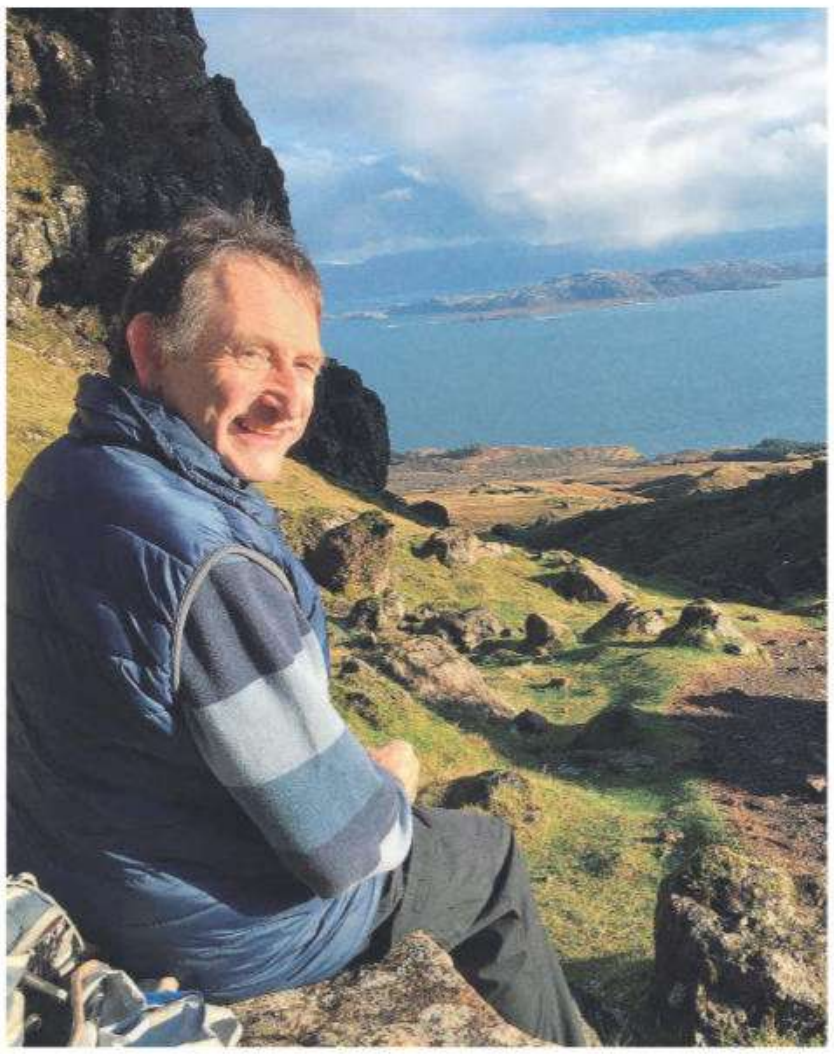
People can be a happy place.

Jo's four children are his. His world is never bigger than with them. Out on a hike. Everyone together. It's when Perthshire is at its most beautiful.

But his favourite bit? When the walk is finally over and the whole family sits down for a proper cup of tea and ever-so-slightly overdone fruit cake.

It's what made his late wife, Sue, happiest. The brood of kids all around her. Stomachs and hearts full. And it's the part he now cherishes most.

That's why he left a gift to Cancer Research UK in his Will.



So more famillies can have more time together.

For **Daniel**, it's been twelve more years with his loved ones – and counting. His Hodgkin Lymphoma diagnosis at just twenty-three was a huge shock. He felt lost, but never alone. His boyfriend Adam holding his hand every step of the way.

After four rounds of chemotherapy and two weeks of radiotherapy, which CRUK pioneered, he was given the all clear.

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Quantum multiverse
Why our reality really could be one of many p18

Environment

First images from a new eye in the sky

This bird's-eye view of Spain's Guadalquivir river and the countryside near Seville (top right), is from the first batch of images delivered by the Sentinel-2C satellite. It was launched earlier in September and will provide data for Copernicus – the European Union's Earth observation programme, which helps monitor agriculture, water quality and natural disasters, including wildfires and floods.

COPERNICUS SENTINEL/ESA

New Scientist Live
Have we been predicting the climate all wrong?
See David Stainforth argue for a different approach on 13 October **newscientist.com/nslmag**

Environment

Plan to refreeze sea ice shows promise

Pumping seawater onto the snow on top of Arctic sea ice can make the ice thicker, a trial has revealed, offering a possible way to preserve sea ice during the summer, reports **Madeleine Cuff**

A BOLD plan to pump seawater over the frozen Arctic Ocean could offer humanity a final chance to save the region's vanishing sea ice.

Field trials conducted this year in the Canadian Arctic to thicken sea ice using water from the ocean below have proved successful, says UK start-up Real Ice.

Arctic sea ice cover is shrinking rapidly in response to climate change. Many scientists expect the region to be ice-free in the summer in the 2030s, even if sharp cuts to emissions are made.

The only way to save the region's summer sea ice – which polar wildlife and Inuit communities depend on – is to find a way to artificially thicken the ice, some researchers say.

Real Ice's solution involves drilling through the ice, then pumping water up and onto the snow that sits atop the ice. The water would flood air pockets in the snow and freeze, turning the snow into ice. This would increase the shelf's thermal conductivity, meaning the cold from the Arctic air would spread through it and trigger the growth of more ice on the underside of the ice.

"Our objective is to demonstrate that ice thickening can be effective in preserving and restoring Arctic sea ice," says Andrea Ceccolini at Real Ice.

The method was first proposed by Steven Desch at Arizona State University and his colleagues in 2016. They estimated that deploying ice thickening over 10 per cent of the Arctic could more than reverse recent ice loss in the region. "I am really excited that the idea is being explored," says Desch, who is a scientific adviser to Real Ice. "We need all the options on the table."

Working with the Centre for Climate Repair at the University of Cambridge, Real Ice has been conducting field trials this year in Cambridge Bay on Victoria Island in Canada. The company says the tests have validated the idea, with a pilot borehole thickening the ice shelf by 50 centimetres compared with a control site between January and May.

REAL ICE/WWW.REALICE.ECO

UK start-up Real Ice has been pumping seawater onto the snow on Arctic ice

Crucially, the results show that the technique triggered 25 cm of natural ice growth on the underside of the ice shelf, says

"Our objective is to demonstrate that ice thickening can preserve and restore Arctic sea ice"

Shaun Fitzgerald at the University of Cambridge. "The results in May confirm that actually, yes, you do get this additional rate of growth of new sea ice from the underside."

The experiment also demonstrated that the brine left after the seawater freezes trickles through the ice back into the ocean, rather than remaining in a frozen layer on top of the ice, which would weaken it and potentially cause earlier summertime melt. "That was very, very encouraging," says Desch.

Deployed at a large enough scale, the technique could buy the Arctic region time while we make the emissions cuts needed to halt climate change, argues Ceccolini. It would also help preserve the albedo effect, in which ice reflects sunlight back into space, preventing further warming.

Real Ice's experiments this year covered an area of ice the size of a football pitch. To make a meaningful climate impact, thousands of square kilometres would need to be treated, requiring thousands of boreholes and pumps. To do this, Real Ice plans to develop an underwater drone that could core through the ice at strategic points to pump seawater onto it. The firm has just agreed a partnership with the BioRobotics Institute at the Sant'Anna School of Advanced Studies in Pisa, Italy, to design the re-icing drones. The aim is to have a prototype ready in 2025 and to test it in the Arctic in the region's 2026-27 winter.

A single drone could cover 2 square kilometres of ice per season. Initial calculations suggest that 500,000 drones would be needed to deliver 500 cubic kilometres of additional sea ice each winter, over an area of 1 million square kilometres. This would cost roughly $6 billion per year, Real Ice estimates.

It could be paid for by governments via the United Nations, suggests Ceccolini. Alternatively, companies could purchase "cooling credits" to fund Arctic restoration projects – Real Ice is one of a handful of firms exploring ways to preserve and refreeze Arctic ice. "From my perspective, it's one of the most benign types of climate intervention," says Ceccolini.

But schemes like this – often referred to as geoengineering – are controversial. Many scientists are cautious about tinkering with Earth systems, worried about the risk of unintended consequences.

"I don't think any of these ideas are viable, and especially not at a scale that would matter," says Julienne Stroeve at University College London. She raises concerns about the scheme's energy requirements, as well as the impact that a loss of snow cover would have on animals such as polar bears and seals, which use snow to dig dens for their young. The only solution for saving Arctic ice is to cut emissions, she says.

Real Ice will return to Cambridge Bay in November for a larger experiment, with five boreholes spanning 1 kilometre of sea ice. The firm plans to confirm how much the ice can thicken when treated at the start of the winter season. "It is so easy to thicken the ice," says Ceccolini. "This is about optimising the methodology." ▮

See page 13 for more on melting ice

Cosmology

A black hole's jets are so huge they are hundreds of times bigger than our galaxy

Alex Wilkins

A PAIR of jets blasting out of a black hole spans 23 million light years, the equivalent of 220 Milky Way galaxies in length. This is so large that it may change our understanding both of black holes and the structure of the universe.

"If you think of jets as a thing, then you could say this is the largest object that we know of in the universe," says Martin Hardcastle at the University of Hertfordshire, UK.

The jets, which Hardcastle and his colleagues have named Porphyrion, come from a black hole in a distant galaxy, some 7.5 billion light years from Earth. The light reaching us from them now started its journey when the universe was just 6.3 billion years old, only about half the age it is now (*Nature*, doi.org/nh95).

The researchers identified the jets, as well as at least 10 other sets of jets that are also millions of light years across, using the Low-Frequency Array (LOFAR) telescope in Europe. Follow-up observations with telescopes in India and Hawaii helped to locate the host galaxy.

To produce such vast jets, the black hole responsible would have needed to ingest about a sun's

"You could say this is the largest object that we know of in the universe"

worth of matter each year for a billion years, says Hardcastle. As matter falls into the black hole over this time frame, some of it will be twisted and accelerated by the black hole's magnetic field, blasting it out into space to form the jets.

In the early universe, matter was more closely bunched together than it is today, which makes the persistence of the jets over such a long time without being interrupted by another cosmological object unusual, says Hardcastle. "This is back in a period of the universe where galaxies are quite active. There's a lot going on, and yet this black hole has managed just to keep blasting away more or less unchecked for a billion years," he says.

"I would have thought something like this was impossible," says Laura Olivera-Nieto at the Max Planck Institute for Nuclear Physics in Germany. "It seems too big to have maintained the [jet] for so long."

Even simulating how such a vast beam formed or what its effects might be is hard because of the distances involved, she says. "It's truly a challenge to try to understand how this is physically possible. We cannot put it in a computer, it's too big."

Porphyrion extends so far that it could affect the formation of other galaxies, injecting energy and magnetic fields into other regions, says Hardcastle. This could help explain the mystery of where the universe gets its magnetic fields from. "It dumps energy and magnetic fields and particles into the voids between the galaxies," says Hardcastle. "That's a mechanism for transporting magnetic fields from very, very small scales to very large scales."

These jets might also shake up some cosmological theories, which assume that objects like black holes don't have influence across so much of the universe.

The work "shows that if you want to understand how the universe's large-scale structure forms and evolves, you then also have to think about how the smaller components of it, like the systems that would make such an outflow, influence it", says Olivera-Nieto. ▮

Technology

Tiny nuclear battery could work for decades

THE most efficient design yet for a nuclear battery powered by radioactive decay could bring the idea of a power pack that lasts for decades closer to reality.

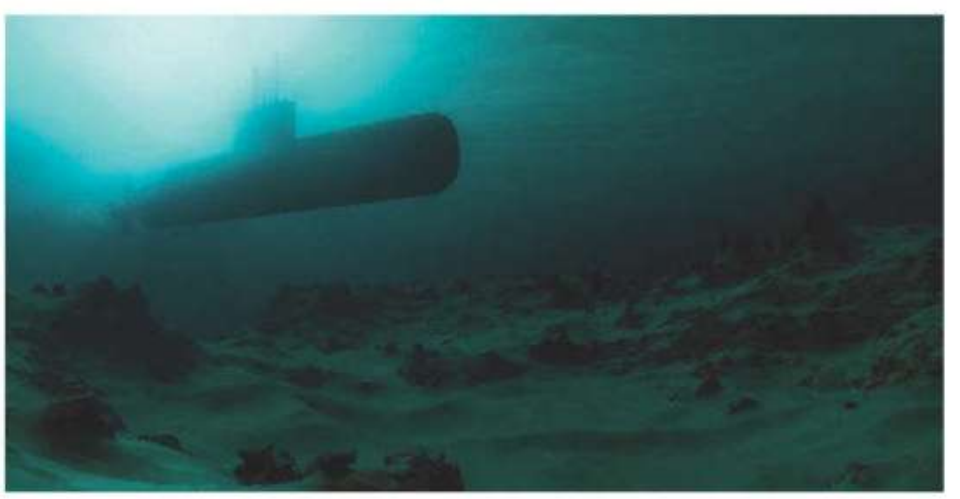
Researchers have wanted to use radioactive atoms to build long-lasting and damage-resistant batteries since the 1900s. Some have been used in space missions, but they weren't very efficient. Now Shuao Wang at Soochow University in China and his colleagues have improved the efficiency of a nuclear battery design by a factor of 8000.

They started with a small sample of the element americium, usually considered to be nuclear waste. It radiates energy in the form of alpha particles, which carry lots of energy but quickly lose it to their surroundings. So the researchers embedded americium into a polymer crystal that converted this energy into a stable green glow.

Then they combined the glowing crystal with a thin photovoltaic cell, a device that converts light to electricity. Finally, they packaged the tiny nuclear battery into a millimetre-sized quartz cell.

Over 200 hours of testing,

Long-lasting nuclear batteries could provide power for deep-sea exploration



EB ADVENTURE PHOTOGRAPHY/SHUTTERSTOCK

says Wang, the device produced a stable supply of electricity with unprecedented efficiency (*Nature*, doi.org/nh94). Although americium has a half-life of 7380 years, the nuclear battery would only last for decades, because radiation would eventually destroy the components.

Although the battery has better efficiency and output than past designs, it produces much less power than conventional batteries, says Michael Spencer at Morgan State University in Maryland. It would take 40 billion of them to power a 60-watt light bulb, for instance.

The researchers are already working on improving their design and envision such batteries being used to power sensors in remote environments, like in deep-sea exploration or space missions. ▮

Karmela Padavic-Callaghan

Environment

New way to split seawater and make hydrogen fuel

James Dinneen

FOR the first time, electrodes that can make hydrogen from seawater without generating corrosive and toxic chlorine gas will be produced at commercial scales.

"Traditional electrolysis has only been possible with pure water, an increasingly scarce global resource," Douglas Wicks at the US Department of Energy's Advanced Research Projects Agency–Energy (ARPA-E) said in a press release.

The new process, developed by California-based startup Equatic, with support from ARPA-E, uses a negatively charged cathode and a positively charged anode to split seawater into four "streams" – useful oxygen and hydrogen, and harmless acidic and alkaline streams. The alkaline stream reacts with carbon dioxide in the atmosphere to form stable minerals that can be poured back into the sea, while the acidic stream can be returned to the ocean once it is restored to a higher pH after flowing over silica-rich rocks.

Like standard techniques that split water to produce hydrogen, this process takes place in an electrolyser, a machine that uses stacks of electrodes to separate water molecules with electricity. To avoid the electrolyser being destroyed by seawater, Equatic co-founder Xin Chen and his colleagues designed an anode that can split oxygen from the water molecules without splitting the salt. They used a chlorine-blocking layer to allow water to flow through the catalyst while stopping the salt.

It is a promising approach to using seawater to make hydrogen fuel, says Pau Farras at the University of Galway in Ireland. "What we need to do is see the real performance in a real environment."

The firm will now begin producing anodes at a factory in California capable of making 4000 of them a year. ▮

Health

The most effective drugs for treating migraines revealed

Christa Lesté-Lasserre

LUZA STUDIOS/GETTY IMAGES

Migraine drugs come in many varieties with differing pros and cons

AN UNDERUSED category of drug appears more effective for managing migraine-related symptoms than newer, costlier medications, according to a review of clinical trials.

Despite being designed to treat migraine episodes, triptan drugs are used in less than 22 per cent of migraine cases. Providing that people who get migraines have no medical conditions that preclude the use of the drugs, such as cardiovascular disease, the results suggest people should consider low-cost triptans as a first-line treatment, says Andrea Cipriani at the University of Oxford.

Triptans, such as sumatriptan and eletriptan, have been progressively authorised globally since 1991 and are now available as off-brand or generic tablets. However, case reports have suggested that the drugs may trigger heart attacks or strokes – especially in people with cardiovascular issues.

To offer alternatives, pharmaceutical firms developed other drugs called ditans and gepants – which have a similar mechanism of action to triptans but avoid the cardiovascular risks. Licensed in the past few years, these drugs – lasmiditan, rimegepant and ubrogepant – come at a high cost. For example, Eli Lilly's trademarked form of lasmitidan, Reyvow, retails for $92.50 per 24-hour tablet, compared with about

22%

The most effective migraine dugs are only used in this proportion of cases

$17 for generic eletriptan.

People also have the option of taking non-steroidal anti-inflammatories (NSAIDs), such as ibuprofen, and analgesics, such as paracetamol, to control their migraine symptoms.

While researchers have carried out hundreds of studies investigating the efficacy, safety and side effects of the many drugs used to treat migraines, there had been a lack of work comparing them, says Cipriani. So, he and his colleagues analysed 137 double-blind, randomised controlled trials done worldwide since 1991.

With a total of 89,445 adult participants, the trials assessed the efficacy of 17 oral medications in comparison with either a placebo or another drug. The team judged the drugs' performance using criteria from the International Headache Society, including how well the medications managed pain over a 2-hour period or throughout 24 hours after regular dosing.

The results revealed that the most effective drug for pain relief at the 2-hour mark was eletriptan, followed by three other triptans: rizatriptan, sumatriptan and zolmitriptan.

Eletriptan and ibuprofen were the most effective drugs for sustained pain relief up to 24 hours (*BMJ*, doi.org/nh6n).

Lasmiditan, rimegepant and ubrogepant, however, were no more effective in relieving the clinical signs of migraine than paracetamol and most of the NSAIDs – and they carried a higher risk of side effects, such as nausea. As such, these drugs should be considered "third-line options", says Cipriani.

The findings suggest that some people would benefit from treating their migraines with certain triptans. But that doesn't mean they are right for everyone, says co-author Elena Ruiz de la Torre at the European Migraine and Headache Alliance, in Brussels. "Migraine is a very personal disease," she says.

Meta-analyses like this tell you about a population, but don't give much insight at a personal level, says Peter Goadsby at King's College London. "You really have to do the best thing for the person sitting in front of you." ▮

Quantum physics

Teleporting energy from empty space

Quantum computing protocol lets you extract energy from empty space, teleport it and store it for later

Karmela Padavic-Callaghan

ENERGY can't be created from nothing, but physicists have found a way to do the next best thing: siphon energy from seemingly empty space, teleport it elsewhere and stash it for later.

The laws of quantum physics say empty space can't exist – even places devoid of atoms still contain tiny flickers of quantum fields. In 2008, Masahiro Hotta at Tohoku University in Japan proposed that quantum entanglement could be used to teleport the energy of these flickers between two places.

In 2023, two research groups independently implemented the idea in a pair of experiments. But both hit the same snag: once energy was teleported, it couldn't be stored – instead, it leaked into the environment, says Sabre Kais at Purdue University in Indiana. Kais and his colleagues have now worked out how to remedy this.

CONNIE ZHOU/IBM

In their protocol, an entangled pair of qubits, or quantum bits – the building blocks of a quantum computer – is in its lowest energy state. For a more conventional object, this would mean it has zero energy. But quantum objects like qubits never have zero energy: they always have some because of the flickers of quantum fields.

"Empty space can't exist – even places devoid of atoms still contain tiny flickers of quantum fields"

Energy teleportation could happen within a quantum computer

Imagine the entangled qubits are separated and handed to two people, Alice and Bob. When Alice takes a measurement of her qubit, it both reveals information about the qubit's fluctuations and slightly increases its energy. Because the qubits are entangled, their quantum state changes as a pair. But Bob can't see that just by looking at his qubit, or without making a measurement that would also disturb the two.

Then Alice calls Bob and communicates the details of the measurement, which tells Bob just how much energy the qubit pair gained from Alice's actions – and how to extract it. Bob uses this information to harvest the extra energy from his qubit. Crucially, he then transfers that energy to a third qubit for storage.

Team member Songbo Xie, also at Purdue University, says the teleported energy is small and fragile, so the storage qubit saves it from getting lost. "This was our goal, to save it for future use," he says. The researchers tested the protocol by simulating the energy transfer on a quantum computer, which is closer to the real situation than a classical simulation would be. The results agreed well with what their calculations predicted (arXiv, doi.org/nh96).

Eduardo Martín-Martínez at the University of Waterloo in Canada, says more definitive experiments are needed to test the protocol.

This is exactly what Kais and his team are currently working on. As a chemist, Kais also has a clear use for the protocol in mind: he wants to use the stored energy to jump-start new and well-controlled chemical reactions. ▮

Global warming

'Doomsday' glacier is headed for a calamitous collapse

A SIX-YEAR investigation into the vast Thwaites glacier in Antarctica has found that the outlook is grim.

Often dubbed the "doomsday glacier", this huge mass of ice is comparable in size to Britain or Florida and its collapse alone would raise sea levels by 65 centimetres. Its melting is also expected to trigger a more widespread loss of the ice sheet over West Antarctica, causing sea level rise of 3.3 metres and threatening cities like New York, Kolkata and Shanghai.

The International Thwaites Glacier Collaboration (ITGC), a joint UK-US research programme, has deployed 100 scientists there over the past six years, using planes, ships and underwater robots.

INTERNATIONAL THWAITES GLACIER COLLABORATION

The melting of Thwaites glacier in Antarctica is expected to accelerate

The team has discovered that the glacier is particularly vulnerable, because it rests on a bed of rock that is well below sea level and the glacier is being melted from the underside by warmer seawater. What's more, the bedrock slopes downwards towards the interior of the ice sheet, so, as the glacier retreats, even more ice is exposed to warm seawater, threatening to accelerate the collapse.

"We know that's unstable," says Mathieu Morlighem at Dartmouth College in New Hampshire, a member of the ITGC team. He and his colleagues used modelling to predict the glacier's future under various levels of atmospheric carbon dioxide, finding that "for almost any carbon emission scenarios, we run into this instability".

"It's not going to instantaneously lead to a catastrophic retreat in the next year or the year after, but, at the same time, we are very sure that Thwaites is going to continue to retreat," says team member Rob Larter at the British Antarctic Survey.

The ITGC researchers think that, by the end of the 23rd century, Thwaites glacier and much of the West Antarctic ice sheet might be lost. ▮

Alison George

Physics

Light takes an impossible journey

Photons seem able to appear on the other side of an obstacle before they have even gone in

Karmela Padavic-Callaghan

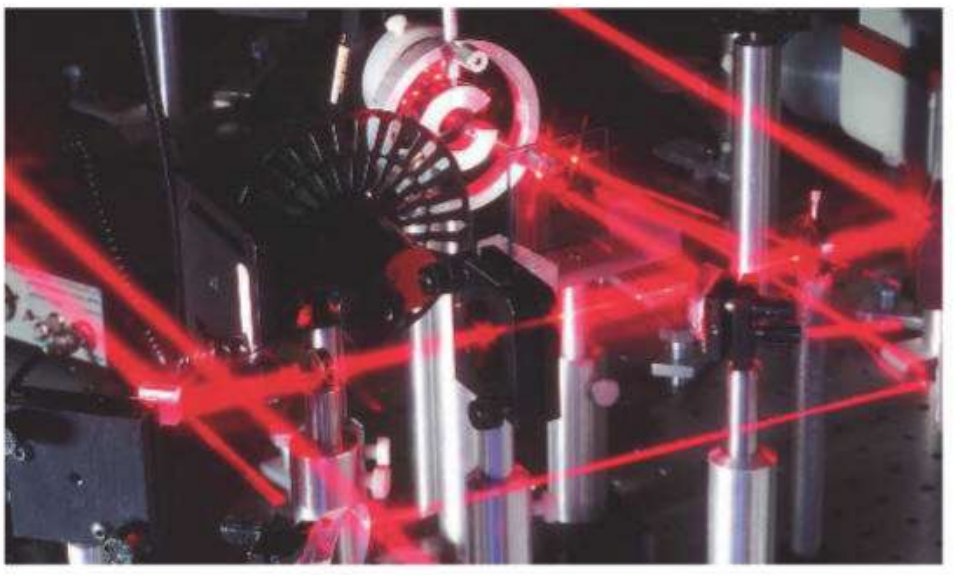
IN THE quantum realm, seemingly impossible things are happening every day. And now an experiment has shown that a particle of light can exit a cloud of extremely cold atoms before it even enters.

When light goes into a material, its speed changes as its particles, called photons, interact with the atoms around them. Atoms inside a material absorb and then release any photons that enter, causing a delay in their travel time. But in some cases, a photon can exit early rather than late – so early, in fact, that it spends a negative amount of time absorbed by the material.

Daniela Angulo at the University of Toronto in Canada and her colleagues sent a photon through a collection of tens of thousands of rubidium atoms cooled almost to absolute zero. Such ultracold atoms are susceptible to quantum effects, and their quantum states can be precisely controlled with lasers and electromagnetic fields. The researchers sent two laser beams through the atoms, each moving towards a different detector.

One beam carried the photons that were either reflected off the atoms or absorbed and then released by them, while the other served as a probe. This probe beam didn't get absorbed, but revealed the change in quantum state that happened when any atom in the cloud absorbed a photon from the first beam. This let the researchers determine if an atom had changed its state while the photon was inside the cloud, and for how long.

Light can seem to break the laws of physics thanks to quantum fuzziness



CHRIS ROGERS/GETTY IMAGES

They were surprised to find there was a combination of laser beam frequency and the atoms' quantum states for which this number was negative (arXiv, doi.org/nh6h). After detecting one such instance, they spent almost two years perfecting their setup, then took data non-stop for weeks to find more, says Angulo.

For quantum objects like photons, there is a fundamental trade-off between how much information about their properties an observer can gather without changing their behaviour. The team opted to make only very weak measurements while photons were in the atom cloud for this reason, but did so repeatedly for up to 15 hours for a single data point, she says.

Team member Aephraim Steinberg, also at the University of Toronto, says although the idea of negative time may seem paradoxical, it doesn't break any rules of causality or Albert Einstein's special relativity because the photons aren't being used to communicate any information. The experiment simply adds to our understanding of all the ways light and matter can interact in the quantum world, he says.

Andrew Jordan at Chapman University in California says the experiment is fantastic, but suggests the results should be taken with caution. "To recall the words of Einstein: time is what is measured by a clock," he says, whereas this experiment obtains the time a photon spent within a group of atoms less directly. He says future experiments should attempt even more direct measurements. ▮

Coronavirus

Wuhan market the most likely source of covid-19 outbreak

AN ANALYSIS of genetic samples from the Huanan seafood market in Wuhan, China, has identified a shortlist of wild animals being sold there that were the most likely source of the virus that sparked the covid-19 pandemic.

While bats are thought to have been the original carrier of the SARS-CoV-2 virus, it has been proposed that an intermediate wild species got infected and ended up on sale at the market, where an outbreak in humans began. Stalls sold live animals as well as seafood.

An alternative suggestion is that the virus escaped from the Wuhan Institute of Virology, where staff were known to be studying bat coronaviruses, but not SARS-CoV-2.

An international team has now re-analysed data from 800 samples collected at the Huanan market by the Chinese Center for Disease Control and Prevention starting on 1 January 2020, and studied viral genomes from the earliest covid-19 cases. Team member Ed Holmes at the University of Sydney says Chinese investigators swabbed surfaces, freezers, drains and cages to test for the virus.

The team found evidence for a variety of wildlife being sold at the market that could have been an intermediate host, including common raccoon dogs, masked palm civets and hoary bamboo rats.

Traces of these animals were found in the same stalls as SARS-CoV-2, says Holmes. "This suggests – but does not prove – that the animals were infected."

"All the scientific data point one way – to a natural zoonotic origin in the Huanan market"

"All the scientific data point one way – to SARS-CoV-2's natural zoonotic origin in the Huanan market, Wuhan," he says.

The genetic studies of the virus in the earliest covid-19 cases revealed that few, if any, people were infected before the market outbreak (*Cell*, doi.org/nh9f).

"There is little doubt about the origins of SARS-CoV-2 coming from the wet market now," says Robert Edwards at Flinders University in Adelaide, Australia. ▮

James Woodford

Space

Bacteria on the ISS are evolving for life in orbit

ON BOARD the International Space Station (ISS), bacteria have evolved new traits to survive in low Earth orbit, and some show signs of increased virulence.

Microbes from Earth have made their way to the station via human hosts and deliveries of equipment and supplies.

NASA has been monitoring the ISS's microbiome for a decade to understand how microbes survive in space conditions and what threat they might pose to astronaut health.

In recent years, researchers have isolated numerous unique strains of bacteria from the ISS with genetic changes that seem to offer protection against the increased radiation and weightlessness experienced aboard the station.

Kasthuri Venkateswaran at NASA's Jet Propulsion Laboratory in California and his colleagues have now studied newly discovered bacterial species found in ISS samples: *Microbacterium mcarthurae*, *Microbacterium meiriae*, *Paenibacillus vandeheii*, *Arthrobacter burdickii* and *Leifsonia williamsii*. They sequenced the genomes of the bacteria and compared them with their closest known relatives on Earth.

"Our study shows that the microorganisms we isolated from the International Space Station have uniquely adapted to survive in space when compared to the Earth counterparts," says Venkateswaran.

Their adaptations include proteins that help the microbes cope with microgravity and improved ways to repair their DNA, which can be damaged by radiation exposure in space.

"These microbes have found ways to live and possibly even thrive in space, and understanding how they do this could have big benefits for space exploration and health," says Venkateswaran.

So far, it is unclear what threat, if any, these bacteria pose to astronauts' health, but Venkateswaran and his colleagues say that some of the genetic traits they identified suggest potential pathogenic capabilities.

The ISS species show enhanced activity of certain genes linked to bacterial virulence, including those that help them evade and damage the immune system. They can

"The microorganisms we isolated have uniquely adapted to survive in space"

also form biofilms, slimy layers that stick to surfaces and can help bacteria resist antibiotics (bioRxiv, doi.org/nh6f).

The findings suggest that astronauts will need to make more effort to control moisture inside spacecraft to prevent the growth of biofilms, the researchers say. They also suggest that the identified genetic traits could become targets for new drugs if these microorganisms turn out to harm humans.

Matthew Baker at the University of New South Wales in Sydney, Australia, says the findings on virulence are "not necessarily alarming", but they do highlight the importance of monitoring microbes on space voyages and taking countermeasures to manage any that may threaten the health of astronauts. ▮ JW

Marine biology

'Shazam for whales' uses AI to ID marine mammals

Jeremy Hsu

A MYSTERIOUS sound emitted from the depths of the Pacific Ocean has finally been identified as a Bryde's whale. Now, artificial intelligence is helping researchers track the elusive whale species responsible for the call.

The puzzle began in 2014 when researchers recorded a sound resembling a moan followed by metallic pings over the Mariana Trench. "Your average person would not think that it was made by an animal – they would think it was some ship or the [US] Navy," says Ann Allen at the National Oceanic and Atmospheric Administration (NOAA).

Years later, more recordings of the sound, called a biotwang, were linked to sightings of Bryde's whales (*Balaenoptera brydei*) at the nearby Mariana Islands.

Bryde's whales are large baleen whales that filter krill and fish from the water, but they are rarely spotted because they are nearly always on the move. Allen saw an opportunity to track these whales by finding biotwangs in more than 180,000 hours of underwater recordings from NOAA's network of hydrophones on the Pacific seafloor.

"It's important any time you can discover a new call type for any species of animal that occurs most of the time out of sight of people because it allows you to use passive acoustic monitoring to detect their presence," says Caroline Casey at the University of California, Santa Cruz.

To sift through the audio recordings, Allen teamed up with Google researchers who had been developing an AI model to identify vocalisations of multiple whale species. Google trained its AI to categorise different patterns in spectrogram images, which convert sound to a visual form.

BLUE PLANET ARCHIVE/ALAMY

Bryde's whales aren't seen often because they tend to be on the move

The AI was able to identify calls – a bit like music-identifying app Shazam – by comparing them with the training set. It successfully identified calls from eight species: humpback whales, blue whales, fin whales, North Pacific right whales, North Atlantic right whales, minke whales, killer whales and Bryde's whales (*Frontiers in Marine Science*, doi.org/nh6g).

The team also found that biotwangs occur most consistently among a specific population of Bryde's whales in the western Pacific. The patterns of calls suggest the whales may be following the movements of an ocean boundary of warm and cool water. Called the transition zone chlorophyll front, this region of the ocean has a high concentration of plankton and other prey creatures that act as a moving buffet for whales. ▮

New Scientist Live

The quest to save the world's largest flowers

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Space

Earth once had a ring like Saturn's, hint crater sites

James Woodford

OLIVER HULL

What Earth might have looked like encircled by a ring of debris

AFTER a near miss with an asteroid 466 million years ago, Earth may have developed a Saturn-like ring of debris that lasted for tens of millions of years – and perhaps altered the planet's climate.

That is according to Andy Tomkins and his colleagues at Monash University in Melbourne, Australia, who have identified 21 crater sites around the world created by falling meteorites during a period known as the Ordovician impact spike 466 million years ago. The researchers say these crater sites were the result of larger objects in a previously unidentified ring being pulled out of orbit and crashing into Earth.

Taking into account the movement of the continents since then due to plate tectonics, all the sites would have been located close to the equator, say the researchers, which is consistent with a ring because these typically form above the equators of planets.

In addition, the team was guided by previous research that had observed a consistent meteorite signature in limestone deposits that were near the equator at that time.

The likelihood of all these crater sites being positioned close to the equator if they were the result of unrelated, random impacts is just 1 in 25 million, says Tomkins.

But where did this ring come from? The researchers propose that an asteroid, perhaps more than 12 kilometres in diameter, passed so close to Earth that it was torn apart by the planet's gravitational pull, creating a ring of debris.

The shadow created by the ring may have led to global cooling and the iciest

466

million years ago Earth could have had its own ring

conditions experienced by Earth in the past 500 million years, but its exact nature is still unclear (*Earth and Planetary Science Letters*, doi.org/nh4h).

"We don't know how the ring would have looked from Earth or how much light it would have cut out or how much debris there would have had to be in the ring to lower the temperature on Earth," says Tomkins.

It is thought that Earth pulls a kilometre-scale object into temporary orbit about once every 10 million years.

Much rarer for the smaller planets like Earth and Mars is for a large asteroid to pass within what is known as the Roche limit – the point at which the tidal forces of the larger body tears apart the smaller one.

The exact distance depends on the characteristics of the two bodies. For a solid asteroid approaching Earth, the Roche limit may be just over 3000 kilometres, while an asteroid made up of loosely compacted rubble would disintegrate at 15,800 kilometres.

Aaron Cavosie at Curtin University in Perth, Australia, says such a disc could explain the 40-million-year duration of impacts and meteorite debris in sedimentary rocks during the Ordovician impact spike, as well as the equatorial distribution of impact craters at the time. It also explains why a spike in similar age impact craters isn't seen on Mars and the moon, he says. ▮

Technology

An AI can beat internet CAPTCHA tests every time

Chris Stokel-Walker

AN ARTIFICIAL intelligence can solve the CAPTCHA puzzles used by websites to distinguish whether users are humans or bots 100 per cent of the time.

Andreas Plesner at ETH Zurich in Switzerland and his colleagues fine-tuned an AI model nicknamed YOLO (You Only Look Once) to solve reCAPTCHA v2 challenges – developed by Google – to verify identities on websites. These ask users to identify objects such as traffic lights among a set of images.

The researchers fed about 14,000 pairs of images with corresponding labels to the model to train it on what the objects look like. Overall, reCAPTCHA v2 focuses on about 13 types of object, such as cars, buses and road crossings. The narrow range of objects, all in the context of a road, made it easier for YOLO to be trained, says Plesner.

They then tested YOLO, looking at factors such as whether it moved the mouse as a human might and if there were browser histories and cookies installed on the test device. This is because it is believed Google's bot-detection algorithms look at these factors – known as device fingerprinting – in addition to the answers given in the CAPTCHA. The AI succeeded at the tests 100 per cent of the time (arXiv, doi.org/nh9t).

"We have a very large focus on helping our customers protect their users without showing visual challenges, which is why we launched reCAPTCHA v3 in 2018," a Google Cloud spokesperson said in a statement. "Today, the majority of reCAPTCHA's protections across 7 [million] sites globally are now completely invisible. We are continuously enhancing reCAPTCHA."

Device fingerprinting may become more important now it is clear image recognition can be done by AIs, says Eerke Boiten at De Montfort University, UK. ▮

Health

The death toll of antibiotic resistance

About 39 million people are predicted to die as a result of this problem between now and 2050

Michael Le Page

THE number of global deaths directly attributable to antibiotic-resistant bacterial infections is forecast to rise from a record 1.27 million a year in 2019 to 1.91 million a year by 2050. In total, antibiotic resistance is expected to kill 39 million people between now and 2050, but more than a third of that toll could be averted if we take action.

Resistance occurs when microbes evolve the ability to survive drugs that were deadly to them, so the drugs no longer clear up infections, making it more likely people will die from them. Because of the widespread use of antibiotics, in farming as well as healthcare, a growing number of microbes are becoming resistant, but the problem's scale is unclear.

To address this, Eve Wool at the Institute of Health Metrics and Evaluation (IHME) in Seattle and her colleagues have tried to estimate the annual number of deaths due to antibiotic resistance from 1990 to 2021. "Our estimates are based on more than 500 million records," says Wool. "We have a lot of coverage geographically and across time." While the overall number of fatalities due to this has been rising, the team found that the figure for young children has been falling as a result of vaccinations and improved healthcare. Between 1990 and 2021, deaths due to antibiotic resistance decreased by more than 50 per cent among children younger than 5, but rose more than 80 per cent in adults over 70.

1.91m

Deaths due to antibiotic resistance expected in 2050

Overall, deaths attributable to antibiotic resistance rose from 1.06 million in 1990 to 1.27 million in 2019 and then fell to 1.14 million in 2021, the team concludes. However, the decline in 2020 and 2021 is thought to be a blip caused by covid-19 control measures reducing other infections, too, rather than to improvements in combatting resistance.

In the study's "most likely" scenario for the decades to come, deaths from antibiotic resistance rise to 1.91 million a year by 2050. In a scenario in which new antibiotics are developed against problematic bacteria, 11 million deaths would be averted between now and mid-century. In a "better care" scenario, where more people also have access to good healthcare, even more deaths are avoided (*The Lancet*, doi.org/gn7jdx).

The 1.91 million annual deaths figure is much lower than an often cited one of 10 million deaths in 2050, from a 2016 review. That forecast was based on less reliable estimates and included the resistance to non-antibiotic drugs in diseases such as HIV and malaria, says team member Mohsen Naghavi, also at the IHME.

The new study is more thorough than previous efforts, says Marlieke de Kraker at Geneva University Hospitals in Switzerland, but still has limitations. For instance, it assumes the risk of antibiotic resistant infections causing deaths is the same around the world, when this isn't the case. "If basic healthcare infrastructure is limited, drug-resistant infections do not necessarily lead to more deaths than drug-susceptible infections," says de Kraker.

She is also sceptical about such forecasts, she says, because drug-resistant versions of microbes can emerge or disappear without us really understanding why. ▮

Zoology

Giant rats trained to sniff out illegal wildlife trafficking

TRAINED rats could help counter the multi-billion-dollar illegal wildlife trade by deploying their heightened sense of smell to catch trafficked animal products.

The non-profit organisation APOPO already uses southern giant pouched rats (*Cricetomys ansorgei*) to sniff for landmines in post-conflict zones and to detect tuberculosis. Now, Isabelle Szott and Kate Webb, then at APOPO, and their colleagues have tested the ability of the pouched rats to detect four commonly trafficked items from endangered species: rhino horn, elephant ivory, pangolin scales and African blackwood.

Between 2015 and 2021, rhinos, pangolins and elephants accounted for 73 per cent of wildlife trafficking seizures by authorities.

The rats could detect the illicit materials hidden in containers and packages even when they were masked by other scents, with false alarms below 2 per cent (*Frontiers in Conservation Science*, DOI: 10.3389/fcosc.2024.1444126).

The illegal wildlife trade is one of the leading causes of the biodiversity crisis, but cracking down on it is resource-intensive and politically challenging, especially across international borders. Current methods to combat wildlife trafficking, such as screening shipping containers with X-rays at crowded ports, are also expensive and difficult to implement at scale.

APOPO

An African giant pouched rat sniffs boxes while hunting for wildlife products

The researchers say that sniffer rats offer an alternative, low-cost way to impede international wildlife trafficking networks.

"The rats have particular skill sets that can complement existing screening tools," says Webb. "They can be easily transferred between trainers, and they are small enough to be lifted onto containers and navigate tight spaces. They also have an average lifespan of eight years, but we have rats as old as eleven years in retirement."

"Deploying rats to combat wildlife trafficking may assist with the global fight against networks that exploit humans and nature," says Szott. ▮

Kate McMahon

New Scientist Live

A talk on the wild side

See Chantelle Lindsay talk about how a love for nature can benefit everyone on 12 October newscientist.com/nslmag

Physics

A quantum multiverse may be feasible

Simulations suggest our reality could be one of the many worlds in a quantum multiverse

Karmela Padavic-Callaghan

COULD we live in a quantum multiverse without ever noticing its oddness? A simulation suggests that the answer is yes.

"We live in a quantum world, as far as the experiments we do can tell. So then why do I end up having all these [non-quantum] classical experiences?" says Joseph Schindler at the Autonomous University of Barcelona in Spain.

To investigate, he and his colleagues started with the equations of quantum theory, which don't offer clear descriptions of objects and their behaviours, but rather describe them as a fuzzy set of possibilities that become definitive only after you observe the object. At that point, it is also seemingly impossible to say what that object was doing just moments before.

Quantum theory can look like it is constraining us to only ever be in the now, says team member Philipp Strasberg, also at the Autonomous University of Barcelona. But that doesn't match our experience of the world.

The "many-worlds interpretation", which asserts that the universe contains infinite parallel worlds, dispels quantum fuzziness by positing that all possibilities are real but happen in separate worlds, one of which may be our classical world.

"We live in a quantum world, so then why do I end up having all these non-quantum experiences?"

The researchers worked with this idea combined with the framework of "decoherent histories", which states that every physical process can be broken into a sequence of steps that happen at definite times, thus allowing quantum objects to have defined records of past behaviour.

This enabled Schindler, Strasberg and their colleagues to create a mathematical model to evaluate how often the multiverse can provide such sensible, unambiguous histories. The model had a simplified system containing two objects that can exchange heat with each other. Using this, they examined how making the two objects bigger, up to several thousand particles in size, boosts the chance of them ending up in a world that obeys classical physics. They found that this happens quickly and nearly every time (*Physical Review X*, in press).

"It's very generic, almost inevitable. This is good news for people who want to live in a classical world," says Strasberg.

Jess Riedel at NTT Research in California says the model could help us probe the fundamentals of quantum theory, but says the model would need to be more complex to reflect something definitive about our world.

However, Robert Griffiths at Carnegie Mellon University in Pennsylvania, who developed the idea of decoherent histories in the 1980s, says his approach is fundamentally incompatible with the maths of the many-worlds interpretation. But he also says the new work raises interesting questions like how decoherence – the process by which quantum objects lose their fuzziness – shapes our world. ▮

New Scientist Live

Our accidental universe

On 12 October, hear Chris Lintott reveal how astronomers make discoveries newscientist.com/nslmag

Zoology

Rebreathing air helps lizards stay underwater longer

SOME lizards can stay underwater for an extended period by blowing out and then rebreathing air bubbles. This has been suspected since the behaviour was first observed, and now experiments have confirmed it.

When underwater, at least 18 species of *Anolis* lizards blow out large bubbles from their nostrils that remain attached to their heads, and then breathe them in again.

These species all have water-repellent skin that remains covered by a thin layer of air when they are underwater, giving them a silvery appearance. This is also why bubbles they blow out stay attached.

To investigate this behaviour, Lindsey Swierk at Binghamton University in New York state has applied a moisturiser known as an emollient to the heads of water anole lizards (*Anolis aquaticus*) with a paintbrush, to temporarily stop the skin repelling water and thus stop them trapping large air bubbles.

These lizards could only blow out tiny bubbles. "They were able to rebreathe a little because I did not apply the emollient over the nostrils, for obvious reasons," says Swierk.

She then put the lizards in a plastic tank filled with stream water to see how long they could stay underwater. Those painted with plain water stayed underwater 32 per cent longer on average than lizards painted with the emollient (*Biology Letters*, doi.org/nh4d).

Swierk thinks simply rebreathing the same air allows the lizards to get more oxygen out of it. In addition, as the blown-out bubble joins up with the thin layer of fresh air on the skin of the lizard, more oxygen will enter the bubble. In other words, the thin layer of air on the skin might act as a scuba tank. ▮

Michael Le Page

LINDSEY SWIERK

An anole lizard with a bubble of air on its head that it blew out through its nose

Environment

People hugely underestimate the carbon footprints of the 1 per cent

Jeremy Hsu

PEOPLE consistently underestimate the carbon footprints of the wealthiest 1 per cent of individuals while overestimating the carbon emissions of low-income people. These misperceptions could undermine efforts to mitigate climate change.

Previous research by Jared Starr at the University of Massachusetts Amherst and his colleagues showed that the richest 1 per cent of the US population is responsible for more carbon emissions than the entire lowest-income 50 per cent.

"If people don't know who is actually creating emissions, it complicates our ability to build public support for policies that would address climate change," he says.

Nielsen and his colleagues surveyed about 4000 people across Denmark, India, Nigeria and the US about their perceptions of individuals' carbon footprints along with their support for various climate policies.

Despite news headlines about celebrities taking 17-minute private jet flights, more than half of survey respondents in the US underestimate the average carbon footprint of the top 1 per cent by a factor of 10.

The misconception also exists to varying degrees in other countries: in Denmark, people underestimate the carbon emissions of their country's wealthiest individuals by a factor of six, in India by a factor of more than 14 and in Nigeria by merely 1.3 (*Nature Climate Change*, doi.org/nh4g). Meanwhile, survey respondents overestimated the carbon footprints of the general population of their countries.

Misperceptions of carbon footprints were found in all socioeconomic groups surveyed. But reactions differed when participants were provided with the real carbon footprints of different economic classes.

The wealthiest people, participants with a more right-leaning political orientation, younger people and male participants were more likely to say the inequality between the carbon emissions of the wealthy and the poorest was fair.

1%

of the US population emits more carbon than the entire lowest-income 50 per cent

In addition, people's underestimations of carbon footprint inequality in Denmark and Nigeria, for example, corresponded with lower support for climate policies such as implementing a carbon tax or subsidising renewable energy.

One unexpected twist in the survey's findings came from India's top 10 per cent income group, which reported stronger support for climate policies. But this probably reflects that higher-income people in India have more access to information about climate change. There is a "huge lack of climate awareness" across India's general population, says team member Ramit Debnath at the University of Cambridge.

More effective climate policies could target those responsible for the largest emissions. Such interventions might include inheritance and wealth taxes, updated building codes and land use regulations, and emissions-monitoring programmes for both private and public organisations, says Ilona Otto at the University of Graz in Austria.

"I hope the results of this study will help to motivate such privileged individuals to lower their carbon footprints, as well as... motivate decision-makers to design policies targeting high emitters," says Otto. ▮

PETER MACDIARMID/SHUTTERSTOCK

Activists including Greta Thunberg protesting against emissions from private jets

Space exploration

How to turn exhaled astronaut breath into fresh oxygen

HERE is a discovery to take your breath away. Missions to the moon or Mars might get more sustainable life support thanks to a chemical reaction that could turn the carbon dioxide exhaled by astronauts into carbon nanotubes and water – which is then converted into fresh oxygen.

Zhaosheng Li at Nanjing University in China and his colleagues have developed a method that continuously pumps CO_2 and hydrogen into a chemical tank. There, the gases encounter a cobalt-based powder that can initiate a chemical reaction when exposed to light.

This creates water, which can be converted to oxygen using an existing water-splitting method. It also produces tiny carbon nanotubes that could potentially be useful for future space missions, for example in specialised materials.

The process achieved 68 per cent oxygen recovery efficiency, whereas the technology that is used on the International Space Station has a theoretical maximum of 50 per cent oxygen recovery. If this could be boosted to at least 75 per cent, it could reduce the space station's water resupply needs enough to save more than $5 million per year (*Joule*, doi.org/nh4f).

"This is greatly achievable on Earth and might be translated into a great, single-supply technology in space," says Volker Hessel at the University of Adelaide in Australia.

The new method still has room for improvement. A better chemical catalyst could reduce the amount of methane produced by the reaction, which is an unwanted by-product, as well as boost the formation of carbon nanotubes, says Li.

The researchers want to refine the chemical process and plan to develop a prototype for extraterrestrial tests, he says. ▮

Jeremy Hsu

New Scientist Live
The balanced brain
Join Camilla Nord as she reframes mental health on 13 October newscientist.com/nslmag

Mental health

Loneliness doesn't seem to cause as many health conditions as we thought

Rachel Nuwer

THE idea that loneliness leads to certain health conditions and a risk of earlier death is being called into question. It might just be correlated with many of the illnesses it was previously believed to cause.

"Loneliness seems to act as more of an indicator of disease rather than a direct cause," says Jihui Zhang at Guangzhou Medical University in China. "Instead, socioeconomic factors, lifestyle choices and genetic predisposition might be driving risk for diseases like diabetes and heart diseases."

Social connection is essential to our mental health and ability to thrive. Yet loneliness – the painful feeling that arises from social disconnection – affects a growing number of people globally.

To learn more about how it affects health, Zhang and his colleagues analysed information from several biomedical databases, including the medical information of 476,100 people in the UK, 16,000 in China and 14,000 in the US. They found that participants who reported feelings of loneliness were at a higher risk of 30 out of 56 individual conditions, ranging from cancers to digestive system conditions.

MONKEY_IMAGES/WWW.PLAINPICTURE.COM

Being lonely is linked to many health conditions, but does it cause them?

Then the researchers performed a second round of statistical analysis on 26 of those 30 conditions, focusing on the subset of participants whose genetic data was available. This revealed that most of the conditions were not, in fact, caused by loneliness. These health problems, including cardiovascular disease, obesity and type 2 diabetes, merely occurred alongside loneliness. But loneliness could still potentially play some role in causing six of the conditions: depression, hypothyroidism, asthma, sleep apnea, substance abuse and hearing loss (*Nature Human Behaviour*, doi.org/nh39).

"Addressing loneliness is important, but it's not the only factor in preventing diseases," says team member Yu He, also at Guangzhou Medical University. "Public health authorities should also focus on improving mental health services and promoting healthy lifestyles."

David Sbarra at the University of Arizona says the study "should give us pause in how we think about the public health goals of reducing loneliness to improve human health".

"Some of the most cherished findings in the field need to be reconsidered," says Sbarra. "It is important to understand where the causal effects might exist and where the correlations seem to exist."

Zhang, He and their colleagues are planning to investigate the underlying biological mechanisms behind their findings, including how loneliness affects things like stress hormones and inflammation. They also hope to run studies on groups of people from other parts of the world to see if their findings – which are predominately based on data from people in the UK – hold up more widely. ▮

Technology

AI detects ancient aqueducts in cold war satellite images

ANCIENT underground aqueducts have been spotted by using artificial intelligence to analyse spy satellite images taken during the cold war.

The oldest known underground aqueducts that are found across much of North Africa and the Middle East are called qanats and are up to 3000 years old. They were designed to carry water from highland areas to irrigate crops in desert regions, and were comprised of dozens of kilometres of channels and vertical shafts used for maintenance and airflow.

"They allowed people to live in areas where it would have been unthinkable before," says Hector Orengo at the Catalan Institute of Classical Archaeology in Spain.

NAZARIJ BUŁAWKA ET AL

Holes at the top of this image are shafts to underground aqueducts called qanats

Orengo and his team created an AI model that can look through black-and-white satellite images for lines of holes that represent the openings of the shafts leading down to the aqueducts. To train it, they used photos taken by US cold war spy satellites that operated between 1959 and 1986, and created additional artificial images of the underground aqueducts to provide more training examples to boost the AI's performance.

They then tested the AI on satellite images from places known to have qanats: Afghanistan's Maiwand region, Iran's Gorgan plain and the town of Rissani in eastern Morocco. More than 88 per cent of the AI's predictions of qanat locations proved correct, and it also correctly identified more than 62 per cent of underground aqueducts in the area (*Journal of Archaeological Science*, doi.org/nh4b).

The AI approach is impressive, but it is unclear if it would find aqueducts in more complex landscapes, says Mehrnoush Soroush at the University of Chicago. ▮

Jeremy Hsu

Botany

Long-stemmed flowers evolved to be 'seen' by bats

James Dinneen

SOME flowers may have evolved long stems to make it easier for echolocating bats to find them.

Like insects and hummingbirds, bats that feed on nectar are important pollinators for hundreds of plant species, including mango and agave. Many of these plants have flowers with characteristics to appeal to bats such as opening at night or giving off a musty odour. The flowers also tend to have long stems that hang down from branches or extend from trunks.

To investigate if stem length is important, Nathan Muchhala at the University of Missouri-St. Louis and his colleagues captured wild tailed tailless bats (*Anoura caudifer*) in the cloud forest in Colombia. These bats have limited vision and navigate by echolocation, emitting high-frequency sound waves that bounce back to them.

The researchers set up net enclosures in the cloud forest and placed a single bloom from the bellflower plant *Burmeistera succulenta* on a post within an enclosure at night, using a wire to vary the length of the stem, and ran tests with 10 bats. In half of the tests, only the flower was attached to the post; in the other half, it was surrounded by foliage.

When the flower was alone, it took a bat the same amount of time to find the bloom whether it had a short or long stem. However, when the flower was surrounded with foliage, as it would be in nature, the bats found long-stemmed flowers almost twice as fast as short-stemmed ones, taking around 18 rather than 30 seconds on average (*New Phytologist*, doi.org/nh38).

This is good evidence that long stems are the echolocation equivalent of "becoming bright red to a bat", says Laura Lagomarsino at Louisiana State University. "They're sticking themselves out where there's less auditory static." ▮

Astrophysics

Dark matter may have let giant black holes form in early universe

Leah Crane

SADOHARU/SHUTTERSTOCK

DECAYING dark matter may solve the mystery of how supermassive black holes formed in the early universe, giving them time to grow into the behemoths that they are now. If dark matter particles exist at the right masses, their decay could cause the black holes to be born big.

There are several ideas for how supermassive black holes form, but one of the simplest is direct collapse, in which a huge cloud of gas in the early universe becomes so dense that it crumples in on itself to create an enormous black hole.

There is just one problem: this shouldn't happen. As the cloud contracts, molecules of hydrogen form and radiate heat away quickly, creating small cold patches that break up the larger cloud in a process called fragmentation. This means there isn't enough matter left in the cloud to collapse into such a large black hole.

Zachary Picker at the University of California, Los Angeles (UCLA), and his colleagues simulated how dark matter could solve this problem. This mysterious substance is thought to make up about 27 per cent of the universe, yet we know almost nothing else about it. But if dark matter particles decay into visible light particles, or photons – which would probably be a rare occurrence – they could

"There isn't enough matter left in the cloud to collapse into such a large black hole"

prevent fragmentation and enable direct collapse to form supermassive black holes.

"Almost all of the dark matter particles we've studied have this bridge to regular matter," says Picker. "Pretty much every dark matter candidate we're looking for does have this decay into photons, because otherwise there's really no way to look for it aside from its gravity."

Certain dark matter candidates that are very low-mass would decay into photons with just the right energy to hit hydrogen molecules in the cloud and smash them to pieces

How did the first black holes get so big so fast?

(*Physical Review Letters*, doi.org/nh4c). And this could give us a way to spot them. "The Hubble Space Telescope can still look for dark matter in this mass range by the light it produces when it decays," says team member Yifan Lu at UCLA.

While these particles would be too light to meet the requirements for the most commonly accepted candidate to make up dark matter, called the weakly interacting massive particle or WIMP, several other candidates fit. One is the axion, which has been proposed to solve other problems in particle physics.

Similarly, direct collapse isn't the most widely preferred model for how to create early supermassive black holes – that would be formation from huge, primordial Population III stars instead of from a cloud of gas – but it is gaining popularity due to recent observations of early supermassive black holes from the James Webb Space Telescope (JWST).

"The masses of supermassive black holes that we could form from Population III stars are much smaller than what we could form from direct collapse, and given that JWST is showing us very large black holes very early on, that's an incentive to think about direct collapse," says Gonzalo Alonso-Álvarez at the University of Toronto in Canada.

Observations of the amount of light in the universe could help us determine if decaying dark matter really does enable direct collapse and the early formation of the biggest black holes. ▮

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Comment

Don't fear the numbers

Anxiety about maths has been around for at least a century. It boils down to a misunderstanding about what maths is, says **Sarah Hart**

MATHS phobia is older than you might think. A hundred years ago, German physicist Felix Auerbach, lamenting the phenomenon and hoping to find ways to address it, wrote a little book called *The Fear of Mathematics and How to Overcome It*. Maths, he said, has so much to contribute to society that addressing this fear is a challenge of the highest importance.

Auerbach was a fascinating character – a scientist but also a patron of the arts. Edvard Munch painted his portrait and Bauhaus School founder Walter Gropius designed his house. For a mathematician like myself, the pleasure of reading his book, now published in English for the first time, is accompanied by a sigh of regret that the topic is as relevant today as it was a century ago.

Why do we fear mathematics? At heart, says Auerbach, it comes down to a fundamental misunderstanding of what maths is. The fear of messing up a calculation may be real, but the fact that there are many excellent mathematicians who are terrible at arithmetic proves that numeracy and mathematics aren't the same thing.

We understand this about writing literature. The art of creating a compelling narrative in beautiful prose is different from the technical skill of getting the spelling and punctuation right. The same is true with maths. It isn't mere calculation.

What, then, is mathematics?

ADRIÀ VOLTÀ

Auerbach says it is three things: a science, a language and an art. For me, part of the issue is that we are stuck in the first box. The incredible utility of maths in the sciences and engineering has meant that it is possible, though undesirable, to teach it only with this utility in mind. A focus exclusively on technical skills misses the joy and excitement that can come from finding patterns and understanding them, from seeing the true beauty of mathematics. That beauty lies in wonderfully elegant thinking that allows us to understand the infinite, explore the sublime symmetries of art and nature, and delight in the perfection of an abstract world of ideas.

As a language, what sets maths apart is the universality of its truths – you can become fluent wherever you are from. As Auerbach memorably puts it, you cannot do "German mathematics with a Japanese accent". But it is the case for maths as an art that is closest to my heart. In researching my book *Once Upon a Prime*, about the beautiful connections between mathematics and literature, I have found many examples of mathematicians and poets praising each other's disciplines. This is no surprise, as mathematics is, says Auerbach, "without exception, a poetic art". If we can be shown the beauty of mathematics, we will forget to be afraid of the technical details underpinning it.

Today's self-help gurus like to point out that, physiologically, we experience anxiety the same way we experience excitement. So, if your heart is racing and your palms are sweating before a big event, you simply have to tell yourself that you are excited. In the same way, fear can be negative (dread) or positive (awe). Our goal should be to try to move people along a continuum from a view of mathematics as a collection of calculations whose impenetrability engenders dread to an appreciation of a profoundly beautiful language whose complexity inspires awe.

A hundred years on, Auerbach's writing is as pertinent as ever. It is a timely reminder that "maths anxiety", as it is now called, remains as much a challenge in 21st century as it was in the 20th. ▮

This is an edited extract from the foreword of The Fear of Mathematics and How to Overcome It *by Felix Auerbach, published by Mathematical Society Archimedes, 2024*

Sarah Hart is professor emerita of mathematics at Birkbeck, University of London

No planet B

Eating green

There has been plenty of controversy over genetically modified crops, but if deployed well they could benefit the environment, says Graham Lawton

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
I recently moved back to my hometown, York, so I'm reading up on the city's rich history.

What I'm watching
Season 2 of Sherwood *on the BBC.*

What I'm working on
Trying to secure an interview with a really big name. Can't say who.

This column appears monthly. Up next week: Annalee Newitz

I HAVE never been a supporter of Brexit, except for one thing: it has allowed the UK to break free from the damaging straitjacket of European Union agricultural policy, including its prohibition on genetically modified crops. I have always believed this was based more on sentiment than science. In post-Brexit Britain, science has won.

Last year, the Genetic Technology (Precision Breeding) Act came into force, allowing the development of gene-edited crops and animals in England. This isn't quite GM, which allows for the insertion of genes from other species, rather than gene editing's approach of only changing an organism's existing DNA, but its potential is very similar (from this point on, we'll just use the term GM). Done right, this could usher in a new era of genetic engineering that unlocks the ability of this tech to undo some of agriculture's environmental damage.

Nearly 30 years on from the controversial introduction of GM crops, they have become a fixture in agriculture. They now cover around 13 per cent of the world's arable land, mostly in Brazil, the US, Argentina, Canada and India.

In those fraught early days, advocates of GM often claimed modified crops were a win-win: they would help to feed a growing population without increasing the environmental impact of agriculture. That was largely because higher yields would reduce the need to expand into natural habitats, and their engineered traits would nullify the need for further intensification.

You might think we would know if this is true by now. But this year a team led by environmental economist Frederik Noack collated research on the environmental effects of GM crops and found that there are still gaping holes in our knowledge.

That isn't for lack of trying. GM crops have been tested in many field trials. These are generally favourable in terms of the impact on producers, showing, for example, increased yields from GM crops compared with non-GM versions, though their impacts on the wider environment are mixed.

GM crops also have complex indirect effects that aren't captured by these trials, which usually have only one variable – GM versus non-GM. Everything else, such as the application of agrochemicals, is held equal. But

> **"Increased drought resistance and improved nitrogen efficiency could make farming much greener"**

out in the real world, the adoption of GM often has ripple effects on agriculture, such as changes in agrochemical use, with what Noack describes as "profound environmental implications".

First, the good news. More realistic experiments have shown benefits along the lines claimed by early GM advocates. One in Bangladesh found that shifting to pest-resistant aubergine increased yields by 50 per cent and reduced use of pesticides by 40 per cent.

But, again, these trials don't capture the full picture. Consider greenhouse gas emissions. Food production accounts for about a quarter of the world's emissions, around a third of which is directly attributable to arable farming.

In principle, adoption of GM crops could decrease this carbon footprint. One analysis found that if Europe were to embrace GM more widely, its emissions from agriculture would fall by 7.5 per cent due to gains in yield. GM crops can also reduce the need for tilling of soil as well as agrochemicals, both of which rely on fossil fuels. But there are large uncertainties about the actual size of these reductions, according to Noack.

On the destruction of habitat, the evidence is mixed. In theory GM crops should reduce the pressure to expand production because yield increases lead to price reductions. But in practice, GM can have the opposite effect. In Brazil, better yields increased farmers' profit margins and incentivised them to encroach into forests. It is a similar story with biodiversity. Some studies show wildlife doing better with GM, others the opposite.

All told, says Noack, "the broader effects [of GM] remain poorly understood". But what the evidence does show, he says, is that GM crops could have "unambiguous positive environmental consequences". The reason they don't is largely because today's GM landscape is dominated by two technologies – herbicide tolerance and resistance to pests – in just four crops: soya bean, maize (corn), cotton and rapeseed (canola). These were developed with profits in mind, not sustainability. Newer and greener tech, applied to a broader range of species, has been held back by steep regulatory costs.

But those advances – things like increased drought resistance and improved nitrogen efficiency – could make farming much more environmentally friendly. What is needed, says Noack, is a regulatory regime that both embraces new tech such as gene editing and emphasises sustainability, not just profitability. Rather, I am hoping, like the new regime in the UK. Bring on the sunlit uplands. ▮

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THE TELEGRAPH

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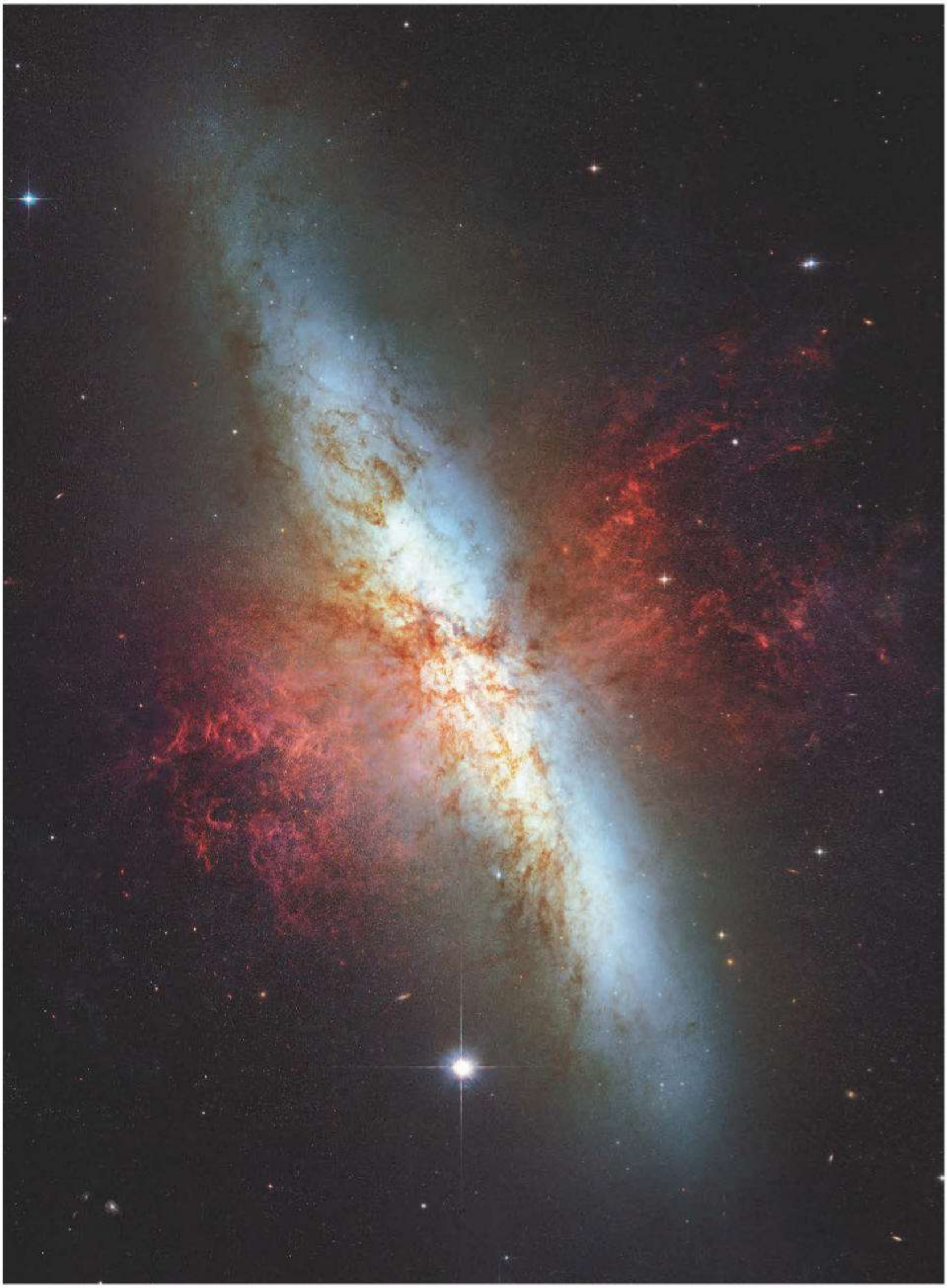

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Stellar views

Becky Smethurst
Publisher Dorling Kindersley

SCARLET plumes of hydrogen emanate from the lively cosmic portrait of the galaxy Messier 82 (M82) shown far left. Also known as the cigar galaxy, it sits in the constellation Ursa Major, around 12 million light years away.

It is what is known as a starburst galaxy due to its remarkably high rate of star formation. In fact, for every star born in the Milky Way, 10 burst into existence in M82. The reason for this much greater activity lies in M82's gravitational interactions with a neighbouring galaxy known as M81.

The fantastic image here is the sharpest wide-angle view of M82 ever captured. It was assembled using shots taken by NASA's Hubble Space Telescope in both infrared and visible wavelengths of light.

Glowing with an ethereal beauty at near left is the Cat's Eye Nebula, or NGC 6543, which was also imaged by Hubble. It is a planetary nebula. Despite the name, these are nothing to do with planets, but form when sun-like stars vigorously expel their outer layers of gas to form a spectacular display. This nebula's concentric, pastel-coloured rings are shells of material emitted in a series of pulses, with around 1500 years between each event.

Both these magnificent scenes feature in the upcoming book *Cosmos: Explore the Wonders of the Universe*, out on 3 October.

"I hope readers will take away both a sense of wonder at how incredible, vast and beautiful our universe is," says astrophysicist Becky Smethurst, who wrote the book's foreword, "but also a sense of how much there is that we still don't know about our universe."

Chen Ly

Playing with fire

There can be no victory in a war against nature, says the author of a must-read history of our environmental crisis. **Michael Marshall** explores

Book

The Burning Earth

Sunil Amrith

Allen Lane (UK); W. W. Norton (US)

COLIN MONTEATH/MINDEN PICTURES/ALAMY

Industrial smoke rises near New Zealand's Kaikoura mountains

SO MUCH has been written about the environmental crisis that it is difficult to say anything new. It is a hard problem, but Sunil Amrith takes a good swing at it.

He is a historian at Yale University, with interests that range from migration to climate history. In *The Burning Earth: An environmental history of the last 500 years*, Amrith documents the ways our societies have impacted the planet over the past half-millennium, from industrial farming to large-scale mining.

The most obvious comparison is Peter Frankopan's *The Earth Transformed*. Both attempt global environmental histories, with case studies drawn from multiple continents. However, Amrith has a narrower focus than Frankopan, whose account covers the entirety of recorded history. In contrast, as his subtitle suggests, Amrith concentrates on industrialisation and the other choices that have directly shaped modern society.

He is also a more engaging guide than Frankopan, with a lyrical style and a talent for storytelling. For instance, his epilogue begins with a discussion of the classic anime film *Princess Mononoke*, which Amrith sees as a parable about humanity's fraught relationship with nature. Topics that could be abstract, overly policy-focused or just plain depressing are brought vividly to life through such devices.

Amrith devotes most of his book to the colonial period and industrialisation. The two phenomena were strongly linked, he says, with European countries conquering swathes of the world in order to gain access to natural resources to grow their wealth. This means that environmental concerns are "inseparable" from "political rights, economic empowerment, and social justice", he argues.

To illustrate this idea, Amrith explores several industries, from Portuguese silver mining in Peru to palm oil production in South-East Asia. At every turn, environmental harms such as pollution and deforestation go hand in hand with the exploitation of people. Amrith documents not just a catalogue of disasters, but the mindset that caused them: a worldview in which everything, from trees and landscapes to animals and people, is seen as an exploitable resource.

"Is a hydroelectric dam working with nature, by harnessing the power of water, or is it dominating nature?"

A particular highlight is his chapter on the two world wars. These epochal conflicts involved all the major powers and drew in combatants from every inhabited continent.

But Amrith argues that they also caused environmental harms on every continent, as embattled nations rushed to obtain essential resources like food and armaments. "Iron-ore came from the mines of Kiruna and Gällivare in Swedish Lapland, from Algeria and Newfoundland and Sierra Leone," he writes.

The central concept to which Amrith returns throughout *The Burning Earth* is how we should think of ourselves in relation to nature. He criticises "the dream of human freedom from nature's constraints", which only the wealthy and arrogant ever wanted.

Hence the parallels with *Princess Mononoke*, in which one of the key characters, Lady Eboshi, builds a convivial town that serves as a refuge for oppressed groups. But to do so she chops down the forest, and the gods of the forest fight back. As Amrith concludes, "there can be no victory in a war against nature".

Instead of seeking to dominate nature, he argues, we should try to live in harmony with it in order to work with it. Herein lies my one quibble. Nobody with any sense would disagree with this rhetoric, but Amrith doesn't clarify what "harmony" means.

Is building a hydroelectric dam working with nature, by harnessing the power of the water, or is it dominating nature by controlling how the water flows? What about nuclear reactors, which use the natural process of nuclear fission? And densely packed cities are intense interventions in nature, which seem bad, but they enable the creation of protected areas elsewhere. So are they good?

But this is a small fault. Amrith's book is a history, not a manifesto. It is beautifully and clearly written, well-researched and finds new perspectives on much-discussed issues. Strongly recommended. ▮

Michael Marshall is a writer based in Devon, UK

A future of our making?

What if tech bros and libertarians ruled the world, wonders **Davide Abbatescianni** as he explores a troubling docudrama

Film

2073

Asif Kapadia

To be screened during the BFI London Film Festival, 16 October; wider distribution to be announced

2073 is definitely one of a kind. Asif Kapadia's new feature premiered at the Venice Film Festival earlier this month and includes elements of documentary, drama, sci-fi and horror. First, he throws us into the dystopian city of New San Francisco, where we find out the world of 2073 has been devastated by some unspecified catastrophe known as the Event – most likely prompted by climate change – sometime in the 2040s.

The planet is now ruled by a group of dictators, libertarians and tech bros who live in their golden cages, exploiting the last available resources and abandoning humanity to death and despair. Kapadia tries to envision what may happen over the next 50 years to lead to this point, zooming in on a woman called Ghost (Samantha Morton), who lives deep in the subterranean levels of a shopping-mall-cum-squatters' camp.

Overall, the sequences set in 2073 are brilliantly crafted, mixing CGI exteriors with interiors shot on location or in a studio. Kapadia's New San Francisco is immersed in fog, battered by sandstorms and poorly lit by a looming red sky. The rich inhabit the highest floors of the few skyscrapers left; the poor live on the lowest levels or underground. The very lucky seem to enjoy life far from Earth, in lush, pleasant, hedonistic space citadels.

Ghost's story is intertwined with extensive flashbacks built out of archival footage and original interviews from the 1990s to 2023. Here, Kapadia tries to touch on the different causes that produced 2073's dystopia. Morton's voice-over narrates – and often rambles – through both the main story and the flashbacks.

She speaks about the rise of the far right, the environmental impact of big tech companies, tech bros' thirst for power and profit, mass surveillance, terrorism, religious fundamentalism and more. Big names feature – including Elon Musk, Mark Zuckerberg, Jeff Bezos and tech companies like Palantir and Meta, as well as despots and controversial political figures like Vladimir Putin, Narendra Modi, Viktor Orbán and Silvio Berlusconi, alongside Italy's current prime minister Giorgia Meloni.

In the flashbacks, the film's flaws begin to surface: its scope is too broad, and Kapadia – constrained by the limitations of a feature-length film – is bound to oversimplify. Society's multifaceted problems go beyond conventional class struggle or the face-off between corrupt conservatism versus enlightened, inclusive social democracy. And while individual facts cited in the film are often correct, the way they are linked can loosely resemble works where shedding light on global issues becomes a platform for diving into conspiracy theories.

On a more positive note, the film's narrative pacing is engaging, and its arguments about not giving up on politics and continuing to fight for people's rights – many of which are drawn from interviews with Nobel prizewinning journalist Maria Ressa and reporter Rana Ayyub – are valid. But their presence, while meaningful, doesn't guarantee that these parts come together.

The film condemns many of the things that the average person – including this reviewer – dislikes most: the lack of control over technological progress, the growing divide between the rich and the poor, and the risk of sacrificing privacy and human rights for a supposedly safer future. But addressing such huge topics in just 83 minutes is virtually impossible. Despite its captivating aesthetic and sincere warnings, 2073 ends up fading into background noise amid today's information overload.

Davide Abbatescianni is a film critic based in Rome

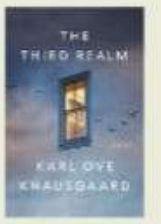
Ghost (Samantha Morton) narrates the dystopian history of New San Francisco

NEON

New Scientist *recommends*

Rowan Hooper
Podcast editor
London

Karl Ove Knausgaard's latest novel cycle began with *The Morning Star*, followed by *The Wolves of Eternity*, and continues with **The Third Realm**. These are books of epic ideas; a pithy summary



is difficult. The characters are mostly from a town in southern Norway, and shining down on them is a star – an unexplained object that just appears.

I read Knausgaard's books compulsively, as soon as I get my hands on them. They are concerned with meaning – of modern life and of reality. He isn't anti-science, but he draws attention to the limits of its explanatory power: in the fuzzy bits, where knowledge runs out, lurk the deepest questions, and this is why I find his books so fascinating.

What happens, for example, at the border between life and death? In this new work, we hear about Russian philosopher Nikolai Fyodorov, who argued for using science to resurrect the dead. By coincidence, Fyodorov also features in the new Richard Powers novel, *Playground* (see page 30, overleaf).

The sci-fi column

Water world

Water world Colonialism, intense friendships, AI: Richard Powers's *Playground* has many strands. But the novel is also a love letter to our oceans and a welcome, urgent wake-up call about destroying wild spaces and creatures, says **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The second book in the series, *Gilgamesh*, is out now. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

JUERGEN FREUND/NATUREPL.COM

Splendours of the deep : a manta ray (*Mobula birostris*) from below

THE distinguished novelist Richard Powers is best known for his novel *The Overstory*. This was inspired by the work of forest ecologist Suzanne Simard, and it was in effect a love letter to trees. It was shortlisted for the 2018 Booker award and won Powers the 2019 Pulitzer prize for fiction.

Playground is the author's 14th novel. It has been longlisted for the 2024 Booker, and there are heavy echoes of *The Overstory*. This time, however, the book is a paean not to trees, but to our vast and still mysterious oceans. Well, that's one strand of it, or the backdrop, perhaps. The novel is also about AI, colonialism, game-playing, exploitation, democracy and also, very strongly, about friendship. There is a lot going on, so it is too simple to call it a book about the oceans.

At the heart of the novel is the intense friendship between a privileged white boy called Todd Keane and Rafi Young, a Black boy from a deprived and violent home. Both end up at an elite Chicago school and form a passionate, highly intellectual friendship that for a while transcends the differences in their world views and backgrounds.

As time goes by, Rafi becomes increasingly obsessed with literature, while Todd forgets his early passion for the oceans and becomes a computer mogul in the style of Mark Zuckerberg.

"Earth is a water planet, yet we are still ignorant of its submerged regions, even as we despoil them"

Then there is the young woman from Micronesia, Ina Aroita, an artist who gets caught between the two young men. Our final main character is a woman called Evie Beaulieu, an early pioneer of diving who becomes a world expert on the oceans at a time when oceanography was entirely dominated by men.

These four characters are fated to meet on the tiny island of Makatea in French Polynesia, which once provided the world with phosphorus. The now scarred and impoverished atoll has been chosen for humanity's next adventure: a plan to develop AI-run cities in the ocean.

For me, the parts of the book that worked best were when Evie was underwater watching huge manta rays pass by above her. I didn't expect to be so moved by these scenes, but now I wish the book had spent more time beneath the waves. I would have liked to learn more about the rays and other creatures she had been privileged to spend time with.

Another nitpick, while I am nitpicking: I don't think the disparate threads worked together as well as they could have, and I felt let down by the ending. One very final nitpick: I found it hard to understand the problems in Rafi and Todd's friendship. This might only be me, though.

But I am picking at very small nits here. Powers is a superb novelist writing at the height of his abilities. The book is magisterial, moving and thought-provoking. It made me want to read more about ocean life in all its complexity and do more to help protect our seas from the ravages of the modern world.

Powers makes the point, very well, that Earth is a water planet, the vast bulk of it covered by ocean. And yet we are still so ignorant of the submerged regions of our world, even as we carelessly despoil them.

So, yes, although this book does a lot of things, it also serves very well as a beautiful love letter to our oceans. Literature that leads us to face up to what we are doing to wild creatures and spaces is vitally important, and I am very glad to have read this. ▮

Book
Playground
Richard Powers
Hutchinson Heinemann (UK); W. W. Norton (US)

Emily also recommends...

Book
Leviathan
John Gordon Davis
Michael Joseph
I haven't read this since the early 1980s, so please excuse me if you find it hasn't aged well. However, I remember it as both very upsetting and extraordinarily moving, with some of it narrated by the whales themselves. It is partly thanks to books like this, I think, that most whale hunting has been banned. Most but not all!

Editor's pick

Wind-powered cargo ship is hopefully just the start

7 September, p 15

From Jonathan Seagrave, Bristol, UK

The maiden voyage of the sailing cargo ship Anemos, with its load of cognac and champagne, is excellent news. However, bulk transport of iron ore etc., which accounts for a large chunk of maritime emissions, must also be made in vessels that use wind as a primary power source.

To be economical, a modern version must be fully automated and uncrewed for ocean passage, something being developed rapidly. There would be many advantages, from avoiding the tragedy of bulk carriers sinking with their crew to a quieter world for cetaceans.

The shipping industry needs to wake up to the reality of primary sail-powered alternatives and recognise there is no way that green fuel will be available in the quantities needed for the sector to reach net zero by 2050. For most purposes, big diesel is dead.

Time to truly recognise animal consciousness

7 September, p 11

From Elizabeth Belben, Radstock, Somerset, UK

You report that individuals in numerous species, including a type of marmoset, seem to call members of their group by name. This suggests they have a concept of individual identity. While people argue about whether computers will ever be conscious, shouldn't we be passing laws to establish the rights of non-human animals who already show signs of being conscious?

Nature's psychological effect is no surprise

31 August, p 40

From Spencer Weart, Hastings-on-Hudson, New York, US

Kathy Willis says that the most calming landscape is an "open one with a few scattered trees". This exactly describes the savannah that our ancestors adapted to after they left the forest and took up hunting, so it makes sense that our brains find it welcoming.

Try this cycling trick to make driving smoother

7 September, p 17

From Peter Jacobsen, Port Townsend, Washington, US

While computer modelling of smoother "eco-driving" shows a reduction in emissions, the question of how to encourage it remains. There are some ideas from the cycling world. One city placed indicator lights on a major street's bike lane 110 metres in advance of a traffic light for riders that signalled how long until the signal would change. Cyclists adapted their pace to make it to the lights without having to stop, reducing travel time. It is likely that such nudges for drivers would also see them learn to adapt their speed. Let's try.

In this tropical zone, too many clouds is a problem

7 September, p 36

From Talia Morris, Cape Tribulation, Queensland, Australia

It is suggested that decreased cloud cover will be a characteristic of a warming world. However, along the Daintree coast in tropical, far-north Queensland, we have experienced the opposite phenomenon. Over the past several years, the number of days in a year with substantial cloud cover has increased noticeably, to the point that it is affecting the region's ability to utilise solar power systems effectively. The number of rainy days also seems to be increasing. Once confined largely to the summer months here (November to February), the wet, as it is known, is increasingly impinging on the winter months (June to August).

Reclaim reality? We never quite had a handle on it

7 September, p 32

From Dave Rowsell, Gowerton, Swansea, UK

Your cover story asserts that we are reclaiming reality. Yet our notion of reality has never really made sense and it has taken quantum physics to discover that. A "thing" with "properties" is actually an infinite regress. And now there might be a "Cheshire cat" effect – properties without their particle "thing" (17 August, p 11). Just what are we reclaiming? And from what?

How to behave, even if morality isn't innate

Letters, 14 September

From Bill Angove, Chester, UK

Andrew Whiteley says the lack of an explanation for intrinsic morality gives no fundamental reason to not pursue personal interest at the expense of others. However, to go against one's moral programming, whether innate or learned, will cause some sort of cognitive dissonance. What's more, society worked out long ago how to respond to those who don't play ball and obey the unwritten rules. They will be ostracised and otherwise punished.

Like OCD, you can't be a little bit autistic

Leader, 14 September

From Ametrine Lavender, Hebden Bridge, West Yorkshire, UK

You point out that obsessive-compulsive disorder "is no joke" and advise against using the term OCD to describe things like ordering your books logically. In a similar vein, can people also stop saying that everyone is a bit autistic, please. As an autistic adult, this undermines difficulties in life related to aspects of my autism.

Valkyrie – personal pronouns, she and her

14 September, p 14

From Sam Edge, Ringwood, Hampshire, UK

You report that the Woodside engineers call NASA's Valkyrie robot "Val" and talk about it in feminine terms. For anyone wondering why, the valkyries were female beings in Norse myths.

I know a good antidote to growing levels of distrust

17 August, p 36

From Derek Bolton, Sydney, Australia

Jamil Zaki notes that 18 per cent of US 17 and 18-year-olds believe that most people can't be trusted. This probably reflects their experience. The internet has made us all disproportionately more aware of individuals who certainly shouldn't be trusted. Right-wing politicians and some industries exploit this, stoking distrust in science and factual journalism. I recommend *New Scientist* as an antidote.

Another vote against the plan to ditch the ISS

Letters, 7 September

From Gerald Lambert, Northleigh, Devon, UK

Along with readers making suggestions about reusing the International Space Station, I really do object to the proposal to dump it back on Earth. It is akin to throwing your empty fizzy drink can out of the car window. Why not boost it to a stable orbit to serve as a scrapyard in the sky to provide parts for future projects?

Want to get in touch?

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Microbes in mind

The surprising discovery that the human brain has its own microbiome offers the possibility of reversing dementia, finds **David Robson**

IN 2015, Nikki Schultek was in her prime: a young mother of two little boys, she had just run a half marathon. Then, a mysterious illness hit. Her asthma, previously well-managed, became increasingly severe. Over the following months, she experienced chronic pain, digestive problems and a cardiac arrhythmia. Then came the "last insult": signs of neurodegeneration, including brain fog and lapses of memory. "It was the lowest point," she recalls. "I began making plans for my kids, writing down notes of things that I would want to tell them if I continued to get worse."

Schultek received various diagnoses for individual problems, but none fully matched her constellation of symptoms. Eventually, one doctor suggested that an undetected infection could lie behind her chronic pain and breathing difficulties. She tested positive for *Borrelia burgdorferi* and *Chlamydia pneumoniae* infections and was prescribed a cocktail of antibiotics. On taking them, she found that all her symptoms – including the brain fog and memory deficits – went into remission.

Schultek has since founded a research group to explore the role of infection more generally in cognitive decline. This idea would once have been considered outlandish, but interest in the brain's microbial community is growing rapidly. It turns out our grey matter is teeming with bacteria, viruses and fungi, and a better understanding of this unexpected microbiome has enormous potential to prevent neurodegenerative diseases. It could even reverse symptoms of decline when things go awry, as Schultek found. And, most excitingly of all, some potential treatments have a proven track record, such as antibiotics and commonly used vaccines.

The burgeoning interest in the brain's microbiome builds on decades of research into the various microbial communities living in and on us. "The past 20 years has seen a switch from thinking that the human body is some kind of sterile entity to realising that microbes are everywhere," says Richard Lathe at the University of Edinburgh, UK. Initially, studies revealed the importance of the gut's ecosystem for long-term health. Now it is becoming clear that our body's microbial residents can influence the functioning of many other organs – and not always for the better. Some may be responsible for the plaques lining people's arteries that result in heart disease. Emerging evidence even implicates bacterial communities in the growth of tumours.

Fortress brain

Until recently, however, the existence of a brain microbiome seemed far-fetched. Our central nervous system is protected by a membrane called the blood-brain barrier, which is supposed to filter out any potential pathogens before they can damage our neurons. What's more, the brain has its own private immune system with foot soldiers called microglia to deal with any intruders. While some viruses and bacteria were known to penetrate this fortress and cause symptoms of severe illnesses such as encephalitis, infiltration was thought to be a rare occurrence. It seemed inconceivable that the brain could host a whole population of diverse microbes.

A few years ago, when one of Christopher Link's graduate students at the University of Colorado Boulder mentioned this possibility, Link was shocked. "I stopped him and I berated him," he says. Afterwards, however, he decided to take a look at the literature, discovering that the evidence base was already much larger than he had imagined – although most of the studies focused on dementia rather than the brain microbiome more generally.

As far back as the early 1990s, Ruth Itzhaki, then at the University of Manchester, UK, had sequenced the genes in post-mortem brain samples from people who had had Alzheimer's disease. She and her colleagues found that the tissue was often riddled with the HSV1 herpes simplex virus – the microbe that causes cold sores. This appeared to be no isolated incident, with further research showing that *Porphyromonas gingivalis*, the bacteria behind gum disease, was similarly prevalent in the brains of people who had died with dementia.

Such findings were initially greeted with scepticism. Some suspected that the microbes were a result of contamination of the samples in the lab. Others suggested that they may have only entered the brain in the late stages of dementia, as a result of the individuals' failing health. "Maybe it's all after the fact," says Link.

Such doubts began to disappear in 2010, when the late Robert Moir at Harvard Medical ›

GRAHAM CARTER

School and his colleagues took a closer look at the beta-amyloid plaques that characterise Alzheimer's. These sticky bundles of protein are toxic to neurons and have long been considered the primary cause of the condition, yet the team's research revealed they had an unexpected function. "Their role is to entrap and kill pathogens," says Lathe. "They are defending the brain." And the discovery that beta-amyloid is found across amphibians, reptiles, birds and mammals suggests that invading pathogens have been a considerable threat to the brain's health for much of evolution. What's more, it indicates a clear mechanism through which microbes might influence the development of dementia. "It was a turning point," says Lathe.

Too many microbes

The mounting evidence leads him to suggest that dementia can result from an increased burden of microbes in the brain as we age. In our younger years, our immune system is strong enough to prevent too many of these organisms reaching our neural tissue. As we get older, however, our defences weaken – a process known as immunosenescence – allowing certain microbes to breach those defences. The beta-amyloid deposits may be a sign of the brain's continued struggle to keep these organisms in check. Once the toxic plaques have formed, however, they may cause collateral damage to the surrounding tissue, resulting in continued cognitive decline – although this is a matter of debate. "I'm certainly interested in entertaining the idea that maybe, even before you're sick, there's this sort of continual challenge from microbes that enter the brain," says Link.

We still don't know how all these microbes end up in the brain, but Lathe notes there are several possible ways they might gain access. Organisms could use our own immune cells as a Trojan horse, for instance. "They could infect macrophages which permeate straight into the brain," says Lathe. Others may have enzymes that allow them to squeeze through small gaps in the blood-brain barrier. Or they might travel along the nerves from the nose and mouth, some of the few direct entrances into our neural tissue. We also don't know whether some of our brain's inhabitants are beneficial. After all, certain microbes in the gut help with digestion, so it is possible that others in the brain aid thinking and reasoning. Link and Lathe are both open-minded about this. "It's not obvious, but it's not impossible," says Link.

"Your brain's microbiome is a subset of the microbes found in your gut"

To get the bigger picture, Lathe recently attempted to take stock of the brain microbiome in people with and without dementia. Working with colleagues at the University of Edinburgh, he examined genetic material from 79 neural samples held in brain banks in the UK and US. The analysis revealed a remarkable diversity of organisms, with as many as 100,000 species per sample. The community included viruses, bacteria and fungi. The researchers even found the remnants of a plant or alga-like organism, though they admit it could have come from pollen that somehow got into the brain. Intriguingly, this microbiome was a subset of the microbes found in the gut – representing about 20 per cent of the species found there.

This raises the question of whether some of the microbes in our brains come from the gut. A recent study in mice found that some pathogens, such as the fungus *Candida albicans*, can slip through the gut lining, hitch a ride with the blood and breach the brain's protective membrane. However, these relocating fungi were mostly found in mice with impoverished gut microbiomes. "The bacteria in the gut [normally] compete with the fungus and prevent it crossing into the rest of the body," says Aimée Parker at the Quadram Institute in Norwich, UK, who led the study. "So, in healthy people, we don't really get fungal translocation." Nevertheless, Lathe's team did find that *Candida* was among a variety of organisms – of unknown origin – that were more prevalent in people with dementia than in those without. "We see

Having a flu shot seems to reduce the risk of developing dementia

MARCO BELLO/BLOOMBERG VIA GETTY IMAGES++

The laws of social connection
David Robson will discuss how social ties bolster health at New Scientist Live on 13 October **newscientist.com/nslmag**

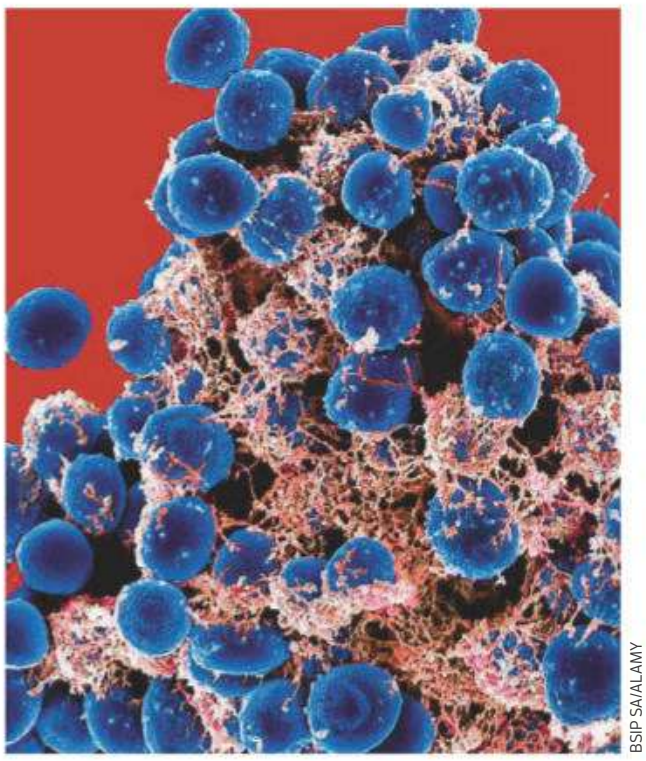
well-known human pathogens such as the bacteria *Staphylococcus*, *Streptococcus*, as well as the fungi *Cryptococcus* and *Candida* are all over-represented in Alzheimer's brain," says Lathe.

Other research suggests that the presence of any single pathogen may be less important in causing dementia than the overall composition of the brain microbiome. Jeffrey Lapides and his colleagues at Drexel University College of Medicine in Pennsylvania recently examined post-mortem brain tissue from 32 individuals, half of whom had had Alzheimer's. Like Lathe's team, they found a large variety of organisms. But they also learned that particular combinations of microbes were associated with different stages of the disease. A group of bacteria known as *Comamonas*, for instance, were considerably more prevalent in people without dementia, while *Methylobacterium* and *Cutibacterium acnes* (which causes teenage spots) dominated the distribution during the later stages of Alzheimer's. We can only speculate about the reasons for these changes, but Lapides suggests that interactions between the different species might put additional strain on the brain. "The chemical results of their competition may be toxic," he says.

Of course, there are other hypotheses that attempt to explain Alzheimer's. However, the idea that the brain's microbiome plays a role need not be at odds with these. "I suspect that there are different things that induce Alzheimer's in different people," says Link. He points out that even having a gene associated with the disease, such as *APOE4*, doesn't dictate how it might develop: "If you're *APOE4*, then you are at a higher risk of cardiovascular problems, you also have lipid transport problems and you also have alterations of your immune response." Each one of these mechanisms may offer a different pathway for Alzheimer's to emerge, he suggests.

But even if a dysregulated brain microbiome only underlies some cases of dementia, it may still play a role in other neurological conditions. One finding hinting at this is that the alpha-synuclein proteins associated with Parkinson's disease also have antimicrobial properties. "When you knock them out in the mice, the mice are more sensitive to brain infections," says Link. Like beta-amyloid, alpha-synuclein may enhance survival in the short term, but – for reasons that are currently unknown – the process could spiral out of control in some people.

Although many questions remain,



BSIP SA/ALAMY

***Staphylococcus* in the brain has been linked with Alzheimer's**

the discovery that microbes are implicated in neurodegenerative diseases already suggests potential new treatments. One obvious approach is to protect the body from pathogens that have been linked to Alzheimer's. Researchers at the National Defense Medical Center in Taipei, Taiwan, for instance, followed people who had received a course of antiviral medication to treat a herpes simplex virus infection. The result appeared to be a dramatically reduced risk of developing dementia over the following 10 years.

Reversing cognitive decline

Other measures could bolster the brain's defences against a whole range of invaders. For instance, the BCG jab – most commonly used as a vaccine against tuberculosis – seems to ramp up the immune system, reducing the risk of many infections besides TB for up to a year. Quite remarkably, and presumably as a result of this, some studies indicate that the injection can cut the prevalence of dementia by as much as 45 per cent. Excitingly, several other vaccines, including flu jabs and the shingles injection Zostavax, appear to offer similar protection.

If dementia results from a problematic brain microbiome, it may even be possible to completely reverse it – a prospect that is unthinkable with our current treatments.

Schultek's recovery from her rapid decline inspired her to search for similar case studies. Working with other members of the Alzheimer's Pathobiome Initiative (AlzPI), the research group she set up, she identified reports of 86 people who had been diagnosed with dementia and then subsequently benefitted from antimicrobial treatments. The pathogens responsible included many that are over-represented in the brain microbiomes of people with Alzheimer's, including *Cryptococcus* fungi. Tellingly, she also found a handful of cases involving *B. burgdorferi* – one of the bacteria implicated in her illness. "It was kind of eerie," says Schultek. "These case reports came from clinicians around the world, but the conclusions were the same nearly every time: that infection testing should be a part of the differential diagnosis."

Schultek suspects these case studies only capture a thin slice of the people who have recovered from cognitive decline in this way. "The majority of clinicians who treat patients don't publish the results," she says. She also believes that rogue microbes in the brain may be the cause of neurocognitive issues in many people. Unfortunately, screening the brain's microbiome without invasive surgery remains a challenge. But cerebrospinal fluid, taken through a lumbar puncture, provides traces of its occupants that could be used for diagnosis. "My personal hypothesis is that if we were to screen everyone, we would find evidence of ongoing, active infection in a significant portion of dementia cases," says Schultek.

Interest in the brain's microbiome is certainly growing. In July this year, the AlzPI held a day-long symposium on the topic, and the Infectious Diseases Society of America now offers funding for Alzheimer's studies. Understandably, the link with dementia still leads research efforts, but, more broadly, there is still so much about the brain microbiome that remains to be discovered. This even includes the identity of some of our brain's inhabitants. "We sometimes see RNA sequences that are not present in any of the genome databases," says Link. He calls this clandestine community the "dark microbiome". "There are probably lots of viruses and other things out there that we don't know anything about." ▮

David Robson is the author of *The Laws of Connection: 13 social strategies that will transform your life*

MARTIN PARR/MAGNUM PHOTOS

Uncommon sense

Generally seen as shared by all humanity, common sense is a lot more idiosyncratic than we thought, with implications for the future of artificial intelligence. **Emma Young** reports

IN THE 18th century, philosopher James Beattie compiled a list of 17 common-sense beliefs. A few are incontrovertible: "I exist"; "A whole is greater than a part"; "Virtue and vice are different". But others seem unnecessarily moralising: "Ingratitude ought to be blamed and punished"; "I have a soul distinct from my body"; "There is a God". Then, there are the scientifically contestable: "The senses can be believed"; "I am the same being that I was yesterday – or even 20 years ago"; "Truth exists". Overall, his list seems quaint and outdated. Worse still, it gives no clear idea of what common sense is. Surely, we can do better.

Superficially, common sense seems easy to define: it is generally seen as knowledge or beliefs that are obvious – or should be obvious – to everyone. Yet it is strangely difficult to pin down. Often portrayed as universal, it is also often claimed not to exist. With that in mind, it might surprise you to hear that nobody has tried to measure the "commonness" of this knowledge or its intrinsic properties (its "sensicality") – until now. Shockingly, this research shows that common sense may not be common at all.

If true, the implications are huge. From parenting to politics and from public health to law, what counts as common sense matters. Increasingly, it is also a technological issue, with computer scientists keen to instil it in artificial intelligence-driven robots to make them behave more like people. So, what do we know about this slippery concept? And how can new insights help us to understand each other better, or build machines we can relate to more easily?

Appeals to common sense have a long history. In 1776, they kicked off the US Declaration of Independence: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights...". Today, judges and doctors regularly rely on common sense when making decisions or issuing advice that could save – or blight – people's lives. Politicians, too, are forever banging on about "common-sense approaches" to national problems. The last UK government even had a minister for common sense. And common-sense reasoning is what we frequently urge children to use – or scold them for lacking. Even so, there is remarkably little research into this everyday concept.

Studies have tended to fall into one of two types. There are those by philosophers and sociologists that discuss the importance, or unimportance, of common sense to people and society. And, more recently, researchers have begun to discuss the desirability and feasibility of replicating common sense in machines. "What these otherwise very different genres share is that they both take for granted that we know what common sense is, and that it is indeed common," says Duncan Watts at the University of Pennsylvania. So, he and his colleague Mark Whiting set out to explore both assumptions.

First, they gathered together 4407 statements that someone, somewhere has claimed to be either common sense or self-evidently true. These came from a range of sources: two years' worth of Google News articles, US political campaign emails, popular aphorisms, two collections of material used to train AI called ConceptNet and ATOMIC, and two datasets that the researchers generated themselves – one by getting online participants to write common-sense claims in 13 categories of life, the other by giving people a half statement and asking them to complete it in a common-sense way. The final list ran the gamut from "All people are human" and "Guns are dangerous" to "You are what you eat" and "If Alex hits Steven, Steven will be upset".

A total of 2046 people were each shown a subset of 50 statements and asked if they agreed with them, and also whether they thought most other people would. Their answers varied, as you might expect given that people don't appear to possess equal quantities of common sense. Watts and Whiting deemed raters whose opinions were those of the majority and who also showed good awareness of the majority opinion to have more common sense than others. Surprisingly, they found that demographic factors, including age, level of education and political leaning, weren't linked to an individual's stock of common sense. And there was only a small association with their scores on an intelligence test. "Having potentially more information about 'the truth', due to being more educated or a more careful thinker, for example, seems not to consistently improve people's ability to understand what other people think about issues," says Watts.

But the study did reveal one thing shared by people with abundant common sense. The ›

"The elusive nature of common sense raises problems for instilling it in AI"

researchers assessed the social perceptiveness of participants using a test called Reading the Mind in the Eyes. This entails examining a series of photos, each zoomed in on a person's eye region, along with a short list of emotions and attitudes, and trying to pick the one that describes what that person is feeling. People with more common sense were particularly good at this. "We suspect this indicates that perceiving what other individuals think is predictive of perceiving what society thinks about an issue," says Whiting.

Intriguingly, these findings hint at what kind of intelligence common sense might be. Priya Kalra at Western University in Canada sees parallels with so-called implicit intelligence. Unlike explicit learning, which refers to knowledge that we acquire deliberately, implicit learning entails the unconscious acquisition of abstract knowledge. For example, if you were to ask a 5-year-old – or even some adults – to explain the grammatical rules of their language, they would probably have no clue where to start, yet they do know them well enough to form meaningful sentences because they have acquired them via implicit learning. Kalra and her colleagues have found that, like common sense, implicit learning ability varies between people, and it is also unrelated to a person's IQ or short-term memory. So, someone may have a high IQ but be poor at unconsciously acquiring knowledge about the world, while for another person the opposite is true. Unfortunately, there is no research investigating people's implicit learning ability and their skill at Reading the Mind in the Eyes. However, Kalra thinks it is entirely possible that they are linked, because people who are better at this test may be more influenced by other people's emotional states, which could lead them to agree more with others and so have more common sense. "But this is speculative," she adds.

Evidence that some people have more common sense than others isn't particularly surprising. But a second finding made by Watts and Whiting is. They reasoned that, for a given statement to count as common sense, the majority of people would have to agree that it was, and individuals would also need to be aware that other people viewed it as such. Very few claims made the cut. And those that did weren't the type enshrined in the US Declaration of Independence. Instead, they tended to be plainly worded, fact-like statements about objective reality, such as "Plants need nutrients in the soil for them to grow" and "Pets should not be taken out during excessive heat".

False consensus

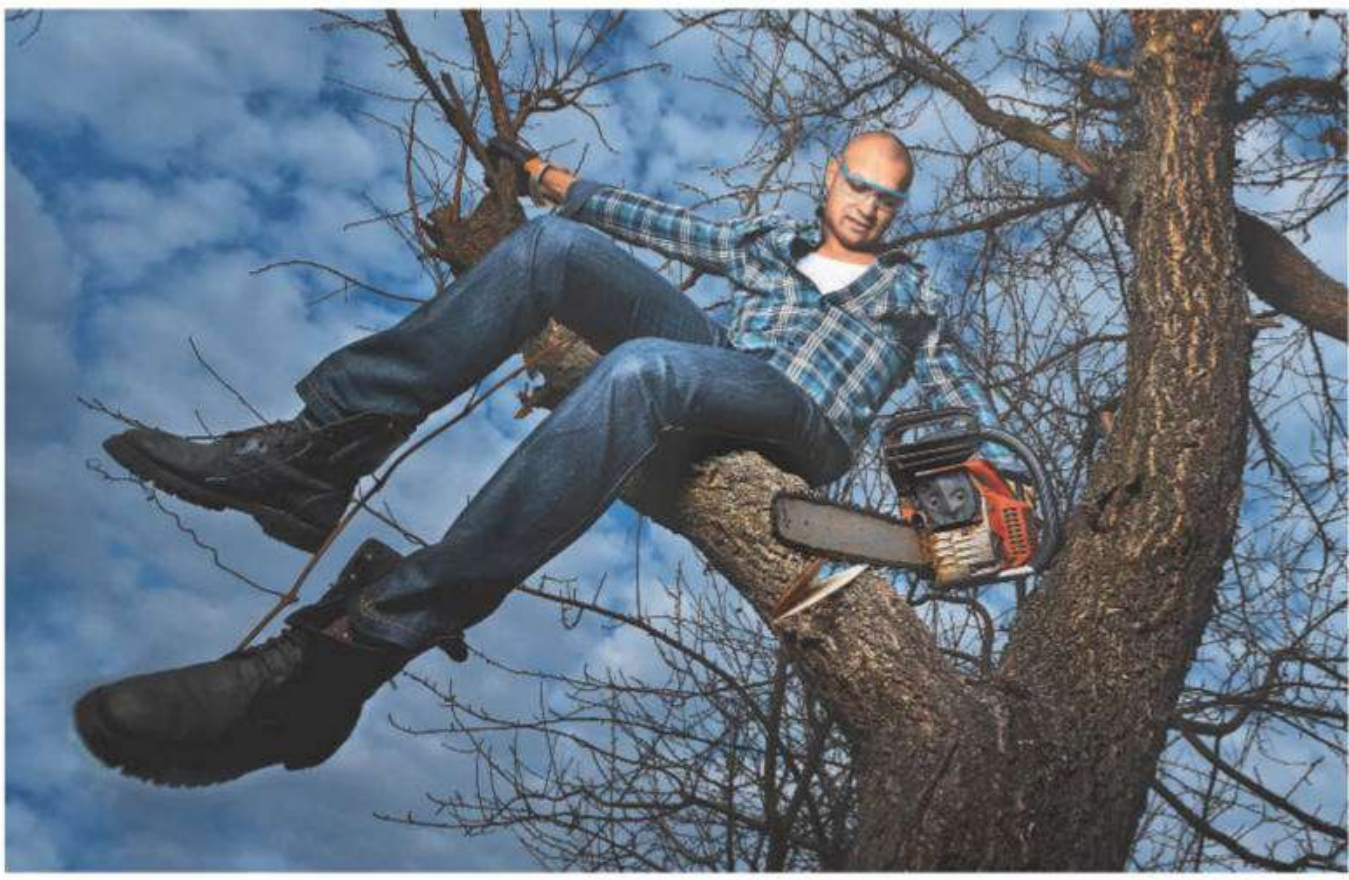
In general, a small fraction of people agreed on a small fraction of statements, leading the pair to describe common sense, as it is usually understood, as "somewhat illusory". In their paper, they conclude: "Common sense attains its legitimacy through the perception of its commonness, yet judgements about what is and is not common sense are in practice idiosyncratic and subjective."

They had anticipated some disagreement between people. "But the extent to which common sense is uncommon is still very surprising," says Watts.

This is curious, given that most people take the existence of common sense for granted. However, it might be explained by one of humanity's many psychological biases, according to psychologist Michelle vanDellen at the University of Georgia, who also doubts the commonness of common sense. The "false consensus effect" describes the finding that people tend to believe they see the world objectively, and therefore their views must not only be right but should also be held by all sensible people. Indeed, Watts and Whiting found that raters tended to believe their views matched those of others, regardless of the actual level of consensus. Another recent study even showed that in the face of clear evidence that someone has listened carefully to our opinions, if they then disagree with us, most of us are convinced they just didn't listen.

If common sense is idiosyncratic, this has big implications outside the lab in all sorts of situations that call for it. As an example, vanDellen highlights disputes during the covid-19 pandemic. Citizens of many countries were urged to use common sense to guide their behaviour. But, she notes, for some people it was common sense to go on holiday with friends who were being careful, whereas for others it was common sense not to interact with anyone outside the home. From a public health perspective, the advice to "use your common sense" is dangerous in two ways,

Your common sense isn't linked to your age, sex or IQ

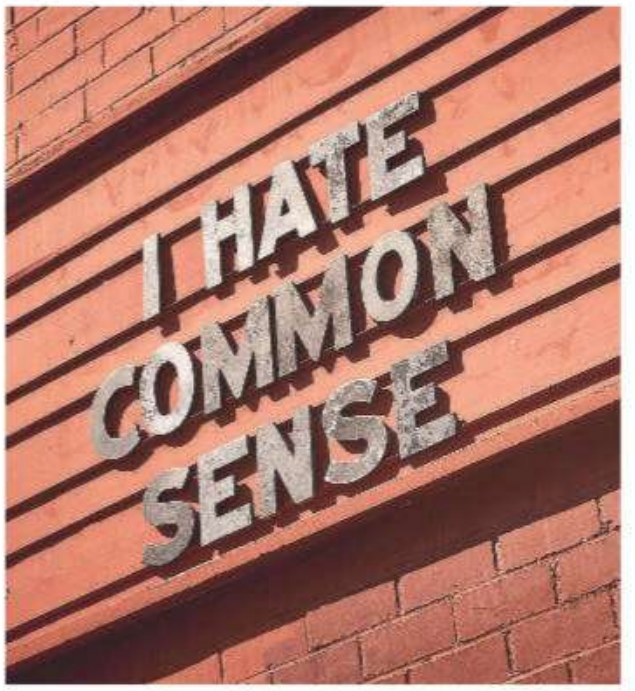


WALLENROCK/SHUTTERSTOCK

How much common sense have you got?

"Happiness can spark a desire to sing." Do you agree? And do you think most people would feel the same way? What about, "Nobody wants to be in a traffic jam" or "Curiosity makes you want to learn more"? These statements are among many featured in a major ongoing study to explore what constitutes common sense – and whether it even exists. Anyone can participate online at commonsense.seas.upenn.edu

The researchers behind the study, Duncan Watts and Mark Whiting at the University of Pennsylvania, recently found that common sense is surprisingly uncommon (see main story). This new project will allow them to explore the subject further. They hope to understand, on a global level, the types of knowledge that can be considered common sense – and how language and culture influence what knowledge people consider to be self-evident.



CHRISTOPH KELLER/ALAMY

she argues. Firstly, it doesn't tell people exactly how to behave. Secondly, it can breed animosity. "If I think we are all acting in accordance with common sense, but you are acting differently than me, it can create a sense of hostility and conflict," she says.

Besides causing friction in human interactions, the elusive nature of common sense also raises all sorts of problems for anyone wanting to instil it in machines. However, Watts and Whiting see a ray of hope here. They believe that although the store of shared common-sense knowledge might be slim for large groups, such as a national population, this might not be the case for certain subsets of these groups. For example, judges may share a pool of legalistic common sense, and likewise for doctors or other medical professionals when it comes to medical know-how. If that is the case, training specialist legal or medical AI bots to have the necessary common sense would be more feasible.

However, for Hector Levesque, a computer scientist at the University of Toronto, when it comes to training AI there is no hard line between topics that are common and those that represent expert knowledge. "And I don't think there is much to be gained – in computer science, anyway – by trying to draw any such line," he adds.

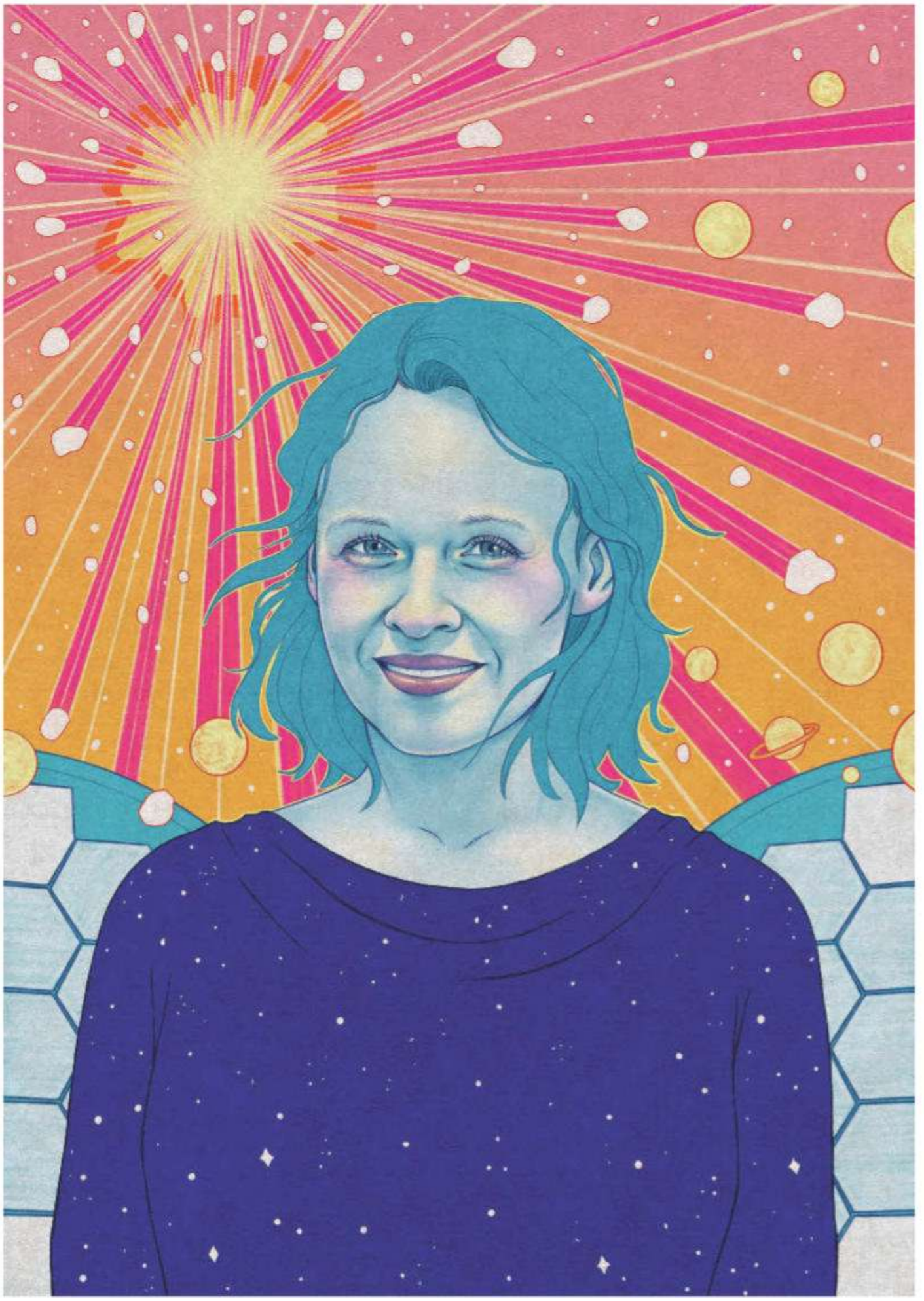
Instead, Levesque argues for a different approach in his book *Machines Like Us: Toward AI with common sense* – written with fellow AI expert Ronald Brachman at Cornell University in New York. "We think of common sense as the ability to make effective use of ordinary, everyday knowledge in achieving ordinary, everyday goals," he says. For example, if you are driving a familiar route to the grocery store and come across a traffic light that happens to be stuck on red, you will quickly realise the problem and find a workaround. By contrast, an autonomous vehicle lacking common sense will just sit there, waiting. With this pragmatic definition, Levesque and Brachman argue, common sense could be built into machines in the "not-too-distant future".

Yanwei Wang at the Massachusetts Institute of Technology is one researcher working on this right now. Most robots are programmed to do one or a small number of fixed things, so they can't adapt to new scenarios, he says. Housework robots, for example, are usually programmed to copy the motions of a human trainer, and they do this very well – until small errors accumulate, or something unexpected happens. Wang and his colleagues aim to get around this by linking the physical motions of a "home-bot" with knowledge contained in AIs called large language models about the subtasks within a given task – cleaning a kitchen, say. This allows the machine to recognise which stage it is on. Then, if it encounters a problem, it can make a new plan and recover on its own. Using LLMs to give robots some degree of physical, practical common sense is a hot topic in the research world, says Wang, "and progress will come soon".

Meanwhile, Watts and Whiting are extending their research in an online project (see "How much common sense have you got?", left). They hope that clarifying the distinction between what is, and is not, common sense could help to ease tensions between people with opposing views on hot-button issues. "If I think it's 'just common sense' that guns should be regulated and you think it's common sense that they should not be, the only recourse either of us has is to think there is something wrong with the other person," says Watts. A clearer delineation between what is common sense and what is personal, subjective opinion could make these disputes more rational, he hopes.

Whatever this ongoing research reveals, the notion of common sense looks set to stay. "It's a human tendency to believe that our ideas are shared with others and unaffected by our experiences and culture," says vanDellen. "People really resonate with the phrase 'common sense'." ▮

Emma Young is a writer based in Sheffield, UK



NATALIE FOSS

Watching the big bang

Astrophysicist **Jo Dunkley** is determined to find out how the universe began. As she explains to Jonathan O'Callaghan, a new telescope might finally provide the answers

SOME 13.8 billion years ago, the universe began in a big bang – or, at least, that is what we think happened. Astrophysicist Jo Dunkley is at the forefront of efforts to work out exactly what took place in the immediate aftermath of that moment of cosmic creation. And a new telescope might just help her answer this question once and for all.

The issue with the big bang is that we can't see it directly. The best we can do is look at the cosmic microwave background (CMB), often called the afterglow of the big bang. Faintly daubed across the whole sky, this radiation is all that is left of the first light that could travel in the universe. Subtle patterns in this light fit with the well-established idea that the big bang was followed by a period known as inflation, when the universe expanded at a rip-roaring pace. But it has never been proven.

Dunkley, who is based at Princeton University, thinks that observing the CMB in finer detail than ever before will clinch the deal, specifically by helping us see patterns imprinted by gravitational waves from the dawn of time. To glimpse these, she plans to use the Simons Observatory, a purpose-built telescope in Chile that is on the cusp of switching on.

As she prepares for this opportunity, Dunkley spoke to *New Scientist* about her hopes of finding new evidence of inflation, what gravitational waves could tell us about the early universe, and the other major mysteries in modern cosmology this observatory could help us resolve.

Jonathan O'Callaghan: Let's start right at the beginning: what is the problem with understanding the dawn of time?

Jo Dunkley: We have this scenario that seems to make sense – after the big bang, the universe had an extremely rapid initial expansion, for a fraction of a second, that took a tiny, lumpy region of space and smoothed it out to produce the vast cosmos that we see now. We call that period inflation, but we don't actually have definitive proof that this is truly what happened. If it did, what was the underlying physics like? What was around back then? It is by no means a done and dusted theory.

So the cosmic microwave background isn't proof of inflation?

I wouldn't say so. The CMB is this snapshot of the universe as it was when it was nearly 400,000 years old. We can extrapolate backwards and infer what could have happened to produce the patterns we see in the CMB. Certainly, inflation makes predictions that match the CMB. But there are other scenarios you could imagine that could produce those patterns. We're not making ›

WORLD HISTORY ARCHIVE/ALAMY

The cosmic microwave background (CMB) emanates from the whole sky

any arguments that the CMB isn't real – this is really an image of the early universe – but we're still trying to find out if this is telling us what definitively happened in the first fraction of a second.

What are the alternatives to inflation?
There are models that propose the idea of bouncing cosmology, where you have a universe before the big bang that shrinks down to almost nothing, then expands again to form our current universe in a way that didn't involve inflation. That could potentially be a more cyclic universe. There are loads of other flavours of inflation as well, where the main variable is the nature of the energy that drove it.

What is the current favoured model of inflation?
Before we had any of the particles we are familiar with now – protons, neutrons, light and so on – we think the universe was permeated by a different kind of energy. We call it the inflaton field, but we really don't know exactly what it was. The energy stored in that field drove this exponentially fast growth of space at the beginning of time. It did so until the inflaton field decayed and we started forming the particles we know and the universe evolved into the form we have now. The very appealing property of inflation is that the seeds of all of the cosmic structures we see around us now, like the Milky Way and galaxy clusters, were put in during inflation as tiny quantum fluctuations.

Are the patterns we see in the CMB linked to these quantum fluctuations?
Yes, absolutely. We think these quantum fluctuations were put in at time zero, in other words right at the instant of the big bang. They would have then evolved and grown: gravity would have started to pull things together and made them larger. If you run the universe forward 400,000 years from the big bang, the prediction of what you would expect to see matches beautifully with what we see in the CMB.

If the CMB doesn't yet prove that inflation is what really happened, can we get that proof somehow?
Yes, there are additional pieces of information that we're trying to get out of the CMB with new data. My colleagues and I have been doing it with the Atacama Cosmology Telescope (ACT) in Chile and we're about to do this more with the Simons Observatory. One of the key ideas is to do with gravitational waves – that is, ripples in the fabric of space-time – that could have been created by the super-quick inflation expansion.

These gravitational waves squeeze and stretch space in a particular way; they squeeze in one direction and stretch in another. That action should polarise the light of the CMB. If the light is unpolarised, you have the same amount of energy vibrating in all directions, but polarised light has a preferred direction. This is similar to what's happening in polarising sunglasses, which cut out some of the light. So, we're looking for this very, very faint polarised signal in the CMB that could only come from gravitational waves.

I guess we haven't seen any sign of this so far. What are our chances of finding it soon?
The current best attempt to see this signal came from the BICEP-Keck telescopes at the South Pole, which measure the CMB polarisation – but no, those have not provided a bona fide detection so far. But we are very excited about the Simons Observatory switching on soon, as the anticipated sensitivity from these two programmes is comparable.

The trouble is, it's a really tiny signal. One of the big challenges is that we have to look through the Milky Way to see out. Also, the signal is mixed up with light that's produced in the galaxy from other sources. Water vapour in the atmosphere is a problem too, as it's really hard to separate out the signal we want from the signature of water – even though we go to some of the driest places on Earth to do these measurements. When the Simons Observatory

BRIAN KEATING/UC SAN DIEGO

is working, we will have measurements from both Chile and the South Pole, where observing conditions are quite different, and that will help us tease out the signal we want from all the noise.

What makes the Simons Observatory so good for potentially spotting this?
We're looking for variations in what we can think of as the temperature of the CMB that are billionths of a fraction of a degree. The polarised signal is a very subtle departure from something uniform. The Simons Observatory will help because it has tens of thousands of detectors, which is 10 times more than previous generations of telescopes such as the ACT.

When will the observatory be operational?
It's undergoing final testing right now, so we hope within the next few months. It's actually a set of four telescopes all on the same site in Chile. The initial configuration is three smaller [0.4-metre] telescopes that are really targeting this gravitational wave signature. And then we have a large, 6-metre aperture telescope, and this will look at the CMB in higher resolution. That's set to be operational in 2025.

What other scientific mysteries will these new telescopes help us tackle?
There are three big problems in cosmology. One is: did inflation happen, which we've talked about. Then there are the mysteries around dark matter and dark energy. Probing each of these three problems is a goal for the observatory.

In addition, there are two big possible tensions in cosmology today, both of which are related to the ongoing expansion of the universe. First, there is the sigma-8 tension, which is the observation that vast cosmic structures like clusters of galaxies may not have grown as big as we would have predicted based on the CMB and our simple model of the universe, called lambda-CDM. Then there is the Hubble tension. The CMB and lambda-CDM model suggest the universe should be growing at a slower rate today than some observations of local galaxies indicate. In other words, the universe may be growing too fast.

The larger telescope at the Simons Observatory should be able to weigh in on these two tensions related to the expansion of the universe. It should also make a better map of dark matter.

It is amazing that all this could be extracted from the faint glow of the CMB...
There's so much richness of information in the CMB. I remember a few years ago people thinking we had measured the CMB, and that was it, done. Then we realised how much there is to know, not only in its polarisation, but as a backlight through the whole universe. It just keeps producing more exciting stuff.

Do you think we are on the cusp of solving some of these key problems in cosmology, like the Hubble tension?
I think we'll know more in a few years. We'll never know the answers to all our questions, but I hope we figure some out. I also hope that something unexpected happens. Usually in science when we have something we don't understand, something we didn't expect comes along to fix it.

These are big questions you are trying to answer. But why do they matter?
We want to know where we came from. How did we come to be here on Earth? To me, it's this idea of trying to fill in the gaps of our big story of where we came from. It might not change our daily lives, but the knowledge of our longer history is enriching. ▮

MARK DEVLIN/UNIVERSITY OF PENNSYLVANIA

The Simons Observatory in Chile has three smaller telescopes (one is shown, left) designed to detect polarisation in the CMB radiation, and a larger one (above) for high-resolution imaging of that radiation

NewScientistLive

Hear more from Jo Dunkley at this year's New Scientist Live. On 13 October, she will be describing the quest to understand the big bang and identify the fundamental ingredients of the universe, including elusive dark matter.

For more information, visit
newscientist.com/nslmag

Jonathan O'Callaghan is a journalist covering space, based in the UK

The back pages

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The science of baking

Sweet choice

Bake Off finalist and chemical biologist Josh Smalley shares his recipe for the perfect caramel sauce with **Catherine de Lange**

Catherine de Lange is the editor of *New Scientist* and an avid baker

SALTY, nutty and irresistibly sweet, caramel can be made in minutes from just a small mound of plain old sugar. The perfect accompaniment to cakes and desserts, caramel is a gourmand's go-to, and we have a jar of it in my house at all times. Working with sugar can be off-putting, however, because it is so easy to burn it (or yourself) and it can also form grainy crystals rather than smooth, glossy sauce.

So this month, I turned to the professionals for advice, going to the University of Leicester in the UK to visit the newly opened Science Kitchen. This lab-cum-bakery is run by chemical biologist and *Great British Bake Off* finalist Josh Smalley, who is using his love of baking to enthuse people about chemistry. He shared his recipe for the perfect caramel sauce.

Wet caramel, which we are making, first involves dissolving the sugar in water. Combine the sugar and water in a small, heavy-bottomed saucepan, and place over a medium heat. Many recipes suggest you keep stirring the solution, but Smalley insists you give it a swirl to mix the water and sugar then leave well alone. Messing with it can cause the sugar to crystallise, which is where things will quickly start to go wrong. Instead, stand back until the liquid starts to bubble.

A dose of sugar chemistry explains what happens next. Generic sugar you use for baking is the disaccharide sucrose, and when this is heated to just over 180°C (360°F) it will break down into its constituent monosaccharides, fructose and glucose. After this happens, various polymerisation reactions will kick in, where these two simple sugars join together into longer, so-called conjugated molecules, which have alternating single and double bonds. These molecules, confusingly called caramelans, caramelens and caramelins, absorb light – which explains why at this point you are going to see the colour emerge in your bubbling caramel solution.

DAVID STOCK

Now it is time for flavour. As you continue to heat, condensation reactions begin to take place and these molecules lose water and become smaller, producing aroma compounds. Each of these has different flavours associated with them. Some are fruity, says Smalley, others nutty or buttery. Collectively, they produce the delicious rich flavour of caramel.

Your mixture is looking brown and bubbly and smelling terrific, but it is literally crunch time because in mere seconds your caramel could burn: so take it off the heat. The simplest way to stop your caramel from heating further is to add some cold ingredients. Whisk in the butter and cream to create a rich caramel sauce, and add a pinch of sea salt if you like it. You can use your caramel to decorate your other bakes – in Smalley's case a swiss roll, pictured. Store the leftovers in a tightly sealed jar and refrigerate.

See Catherine baking with Josh Smalley at newscientist.com/video

What you need

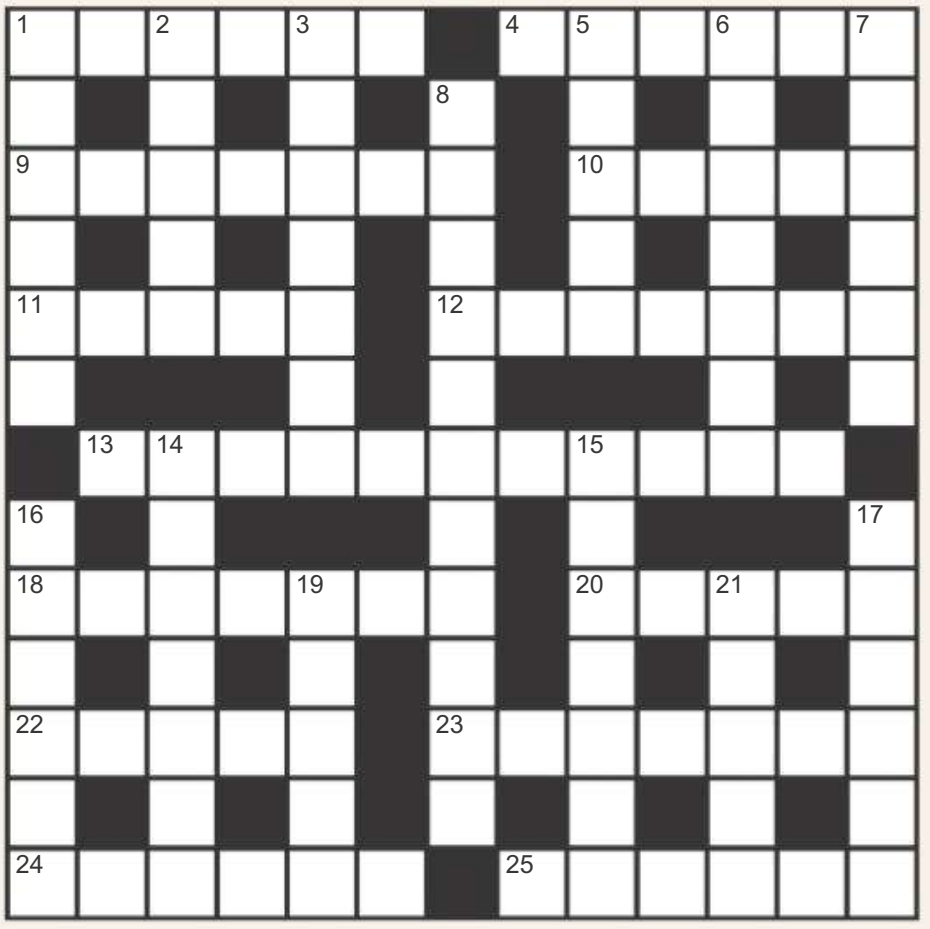
200 g (1 cup) sugar
About 40 ml (3 tbsp) water
100 g (7 tbsp) butter
120 ml (½ cup) double cream or heavy cream
A pinch of sea salt (optional)

The science of baking appears monthly

Next week

Dear David

Cryptic crossword #145 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Illicitly reproduce gas containing iodine (6)
4 Apple and Vimeo heads with a pitch for online icon (6)
9 Orbital voyager, first in space, has place with family on return (7)
10 Purplish kind of light seen in West, possibly (5)
11 "White, not English" it was recorded (5)
12 He meant to diffuse colourless gas (7)
13 Outfit to pocket diamonds, perhaps (7,4)
18 Copper taking charge of endless paperwork with minute element (7)
20 Badger angrily, later (5)
22 Parkinson's treatment for A. Leopold, unwell after Leo's retirement (1-4)
23 Fifty fundamentals – outlaw agricultural toxins, for starters – that might protect against chemical spills (3,4)
24 Remove German pipeline (6)
25 Behind us, at sea, like seabird (6)

DOWN

1 With support of state, father's in unit for stress (6)
2 Dance curtailed by nautical line (5)
3 Bird partially caught in a mousetrap (7)
5 Throw up peace sign over US institution (5)
6 Revision of autism diagnosis, at heart, is destructive phenomenon (7)
7 Part of glacier that's outstanding – like a king, we're told (6)
8 Quickly read and exploit weaker version of browser's output (7,4)
14 Pine for left-wing club (7)
15 Holy man with flowing garments producing flickering lights (7)
16 Ascended like a salmon! (6)
17 Protein is part of bottom number (6)
19 Is sound file for one such as Newton? (5)
21 Convention requires first four to fall from high-wire (5)

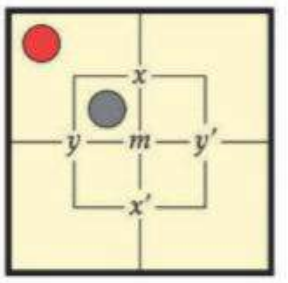
Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #271
set by Bethan Ackerley

1 What connects these names: Alois, Jules, Adolf, Maurice?
2 The Rudolphine Tables are a star catalogue and planetary tables created by which astronomer?
3 Andrea Ghez and Reinhard Genzel are most associated with which object in the Milky Way?
4 Atoms of different chemical elements that have the same number of nucleons (protons or neutrons) are known as what?
5 Yuri Gagarin piloted which spacecraft in 1961 to become the first human in space?

Answers on page 47

BrainTwister
set by Peter Rowlett
#39 Game of logic



Lewis Carroll's Game of Logic involves placing counters on a board to represent logical statements. The top half of the board is x and the bottom half is "not x", denoted by x′. The left and right halves are y and y′. The middle sections are m, and the outer sections are m′ (not labelled).

Say x means "new cake", y means "nice cake" and m means "wholesome cake". A red counter on the board means some cakes are in that section, and a grey counter means no cakes are in that section. The arrangement above says there are cakes that are new and nice, but none are wholesome. Where would you place a red counter to indicate there are some cakes that are new and wholesome, but not nice?

In this cake example, Carroll mentioned some "remarkably untempting" old cakes that are unwholesome and not nice. Can you place a counter to represent them?

Start with a fresh board and represent this statement: "some wholesome cakes are new, and no wholesome cakes are not nice". Are there nice cakes?

Solution next week

Homeward bound

Why does the return journey always seem much shorter than the outward leg on a day trip?

Sue Roffey
London, UK
There are two related parts to the answer. The first is that, if the outbound journey is relatively new to you, then it probably will actually take a little longer, as you drive a little slower, looking out for landmarks and turns, and so on – maybe less so these days if you have GPS and trust it!

The second is a related piece of psychology: your appreciation of the passing of time is substantially affected by the amount of attention you are giving to it. So, you pay more attention on the outbound journey, for the reasons above, and you inevitably give less attention to the return, particularly when back in the home area that you know well – indeed, it sometimes feels like you don't remember making all those much-practised turns and stops!

"We experience fewer novel events that seem worthy of remembrance as we age, and so time seems to increasingly fly by"

Armin Nikkhah Shirazi
Ann Arbor, Michigan, US
Psychological research provides evidence that we don't perceive the passage of time per se, but the change of events in time.

This has been used to provide a potential explanation for why time seems to pass faster as we get older: we experience fewer novel events that seem worthy of remembrance as we age, and so time seems to increasingly fly by.

Applied to a day trip, this suggests that since the return trip only recapitulates things already experienced on the outward leg (like passing a noteworthy sight, for example), it isn't as novel or memorable, and therefore it seems to pass more quickly.

Like any good science-minded person, you shouldn't just accept what somebody tells you, but try to test a hypothesis.

On your next day trip, plan a return route that is different from the outward leg, subject to the following conditions. First, it should objectively take as long as the first leg. And second, it should contain some interesting sights along the way – the more of these the better.

See if your perception of the length of the return trip is different. If it seems as long, you probably found your explanation. If it still seems shorter, you would need to consider a new hypothesis. If it seems longer, you might need to refine the hypothesis.

Kieran Evans
Horley, Surrey, UK
I very much experience this phenomenon, specifically in the case of shorter out-and-back trips. When exploring a new place by car or on foot, I like to drive or walk down dead ends to see what is at the end, sometimes with the promise of an attraction of some sort, like a canyon, a hike or a view. On these occasions, the return leg always feels like it passes in half the time or less.

One of the most extreme examples of this was driving 20 kilometres down a dirt track in Iceland, up a hill with no access points, frequent snow on the road and in a car that wasn't really suitable for the job.

On the outward trip, the kilometres ticked by painfully slowly as I anxiously drove deeper into the wilds. I eventually arrived there safely and the canyon I saw and walked through was worth the trip. The return down the same road passed in the blink of an eye and I came up with the following reasons for why this was the case.

First, the return trip is a return to safety, and hence far less likely to cause anxiety – time will pass more quickly when one isn't anxious. Second, the return trip was over familiar territory. Knowing what was coming next and hence being able to tick the landmarks off made the journey easier to quantify in my head and pass more quickly.

Third, when the entire journey was considered as a whole, I was now past the halfway point, hence the remaining distance to cover felt more manageable and passed more quickly.

Hillary Shaw
Newport, Shropshire, UK
Because we know more landmarks nearer home than further away. Imagine hearing a beep each time we pass one. Going out, the beeps slow down as they become further apart, and are more frequent as we return. This gives an impression of faster speed coming home.

Olwen Williams
Cambridge, UK
If you are starting on a bike in Cambridge, the return journey is inevitably downhill.

CPHOTOSTOCK/ALAMY

Why do cats like this handsome specimen choose to lie on piles of paper so often?

This week's new questions

Cosy spot **Why do cats like to sit on newspapers and magazines?** ***Bethan Ackerley****, London, UK*

Wind speed **If an athlete consumed flatulence-inducing food, could the resulting emissions provide enough jet propulsion to enable victory rather than coming second, given the tiny margins in sprint races?** ***Richard Swifte****, Darmstadt, Germany*

Caught in a trap

My humane mousetrap's instructions tell me to release my visitor a mile away or it may find its way back. Can this be true?

Garry Trethewey
Arkaroola Wilderness Sanctuary, South Australia
The idea of a humane mousetrap introduces some notion of ethics,

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Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist

ON THE 28TH OF JUNE 2009, PROFESSOR STEPHEN HAWKING HOSTED A PARTY FOR TIME TRAVELLERS, BUT HE DID NOT SEND OUT INVITES UNTIL THE DAY AFTER THE PARTY
...NO ONE CAME.
BABYSITTER CANCELLED
HAD TO WORK LATE
TIMESHIP BEING FIXED
DIDN'T FEEL GREAT
HAD TO BE UP EARLY
WORMHOLE CLOSED
DIARY MIX-UP
DOG ATE INVITE

which runs up against population dynamics and carrying capacity.

The mice living a mile away are using all the food and living space that is there. If they weren't, then from the huge number of baby mice that are born, a few more would survive to fill up the space.

So adding another mouse from your house just means there is one more mouse than carrying capacity allows.

What happens then? Perhaps one more of the countless babies dies to accommodate your mouse. Or more likely, your mouse, not knowing the local resource base, dies. Or there is a shuffling – after all, now there is a spare space at your house for the mouse next door to move in, leaving another space, and so on.

Whether it is your original mouse, or another one, you can be sure the space will be filled.

Geoffrey Mann
Bookham, Surrey, UK

I construct my humane mousetrap by building a ladder of books up to a deep waste bin,

"If you take a trapped mouse a mile away from your house, it means there is now a space for the mouse next door to move in"

the last book baited and balanced over the edge. Setting this in the garage for several nights, I caught a mouse every morning and freed it on the common about 100 metres away over a road. I forgot the next night – no books, no bait – but there was a mouse again in the bin. It must have been the same mouse climbing adjacent shelves and jumping in, expecting food and a convenient taxi home in the morning.

Seeing is believing

How do I know if what I see is actually there? (continued)

Do Kester
Zuidhorn, The Netherlands

The answers provided by correspondents up to now have addressed the question from the wrong side. The real question is: Why do we see at all? And subsequently, what do we see?

To answer these questions, we have to go down the evolutionary path. A very long time ago, eyes developed several times independently, in different branches of the evolutionary tree – like legs, neural networks (brains), heads, et cetera.

The fact that eyes developed several times and very long ago means they are important to the individuals that have them, for looking around to find prey or to avoid being predated. It is a matter of life and death to get it right.

Moreover, it will only be selected for in the next generation if the eyes got it right. All variations of eyes that "see" things that aren't there turn out to be dead weights and will fall off the evolutionary path.

So here is your answer: we can be quite sure that what we see is actually true, because evolution doesn't support useless stuff. ▮

Answers

Quick quiz #271 *Answers*

1 First names of scientists whose surnames were given to medical conditions: Alzheimer's disease, Cotard's syndrome, Weil's disease and Raynaud syndrome
2 Johannes Kepler
3 Sagittarius A*, the supermassive black hole at our galaxy's centre
4 Isobars
5 Vostok 1

Quick crossword #167 *Answers*

ACROSS 1 Right, **4** Cirrhosis, **9** Gnu, **10** Ion, **11** Soluble, **12** Lode, **13** Watercress, **15** Gould, **16** Telephone, **17** Late-onset, **21** Eight, **23** Chimpanzee, **24** Eggs, **27** Oxidise, **28** Mix, **29** Run, **30** Ergonomic, **31** Ninth

DOWN 1 Rigel, **2** Goundou, **3** Twin, **4** *Contact*, **5** Roswell, **6** Helicopter, **7** Sub-zero, **8** Spec sheet, **14** Adsorption, **15** Galactose, **18** Twining, **19** Sunbeam, **20** Thermic, **22** Gagarin, **25** Synth, **26** Axon

#38 Rotating dice *Solution*

There are 24 ways to place the cube. You can put any of the six faces on top, with four ways to orient the side faces. A cube also has 13 axes of rotation, yielding 24 rotations: three axes through the centres of faces, each rotating by 90, 180 or 270 degrees; four through opposite corners, rotating two ways each; and six through the centres of opposite sides, each with one rotation. The non-rotation makes it 24. For a cube, and any regular solid, the number of rotations is equal to the number of ways it can be placed, and is 2n, where n is the number of edges.

Hairy situation

Yes, when someone pulls your hair – if you have enough hair that someone can pull it – it hurts. But the truth of why that is, and some of the how much and some of the how, has only recently become evident, thanks to a team of researchers scattered across several countries. Reader Sarah MacIntyre brought their work to Feedback's attention.

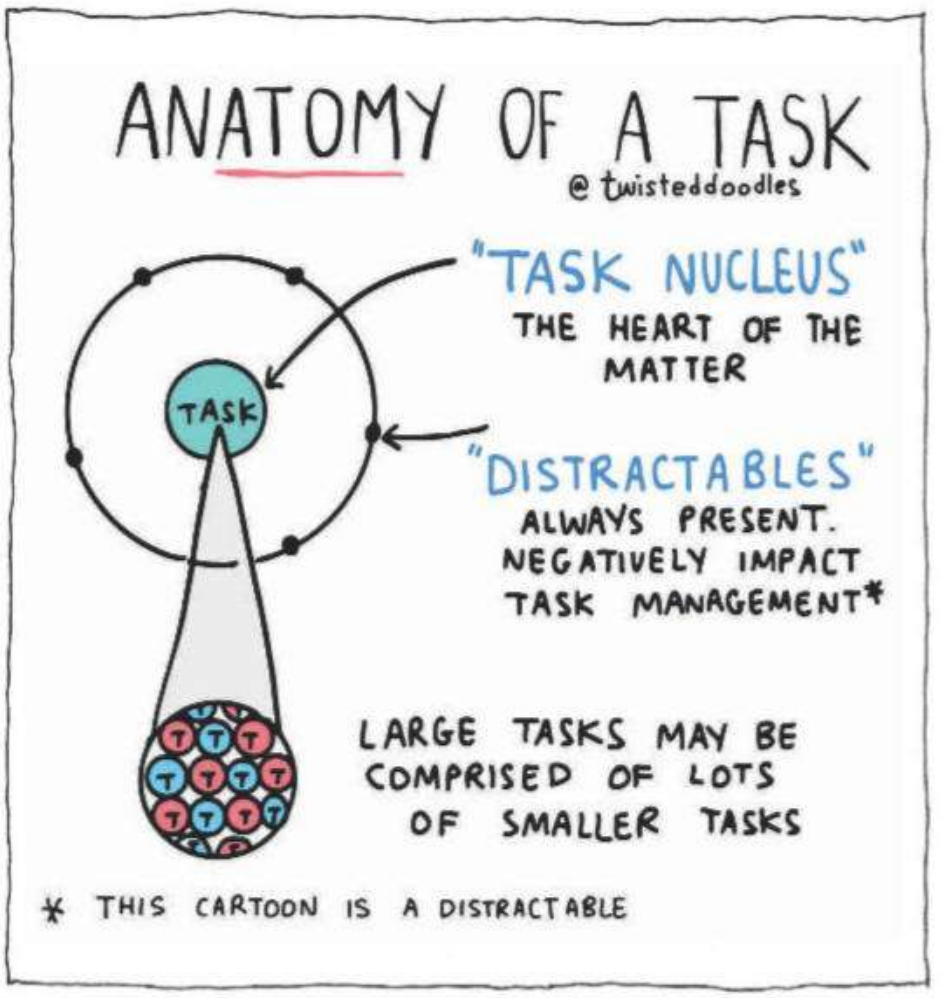
The researchers are – there's no better way to say this – painstaking in how they describe their discovery: "Single-unit axonal recordings revealed that a class of cooling-responsive myelinated nociceptors in human skin is selectively tuned to painful hair-pull stimuli."

They took pains, also, to explain their work in a more human (rather than just technical) manner: "Together, we have demonstrated that hair-pulling evokes a distinct type of pain with conserved behavioral, neural, and molecular features across humans and mice." And yes, we share this hair-pulling pain-specificity with our distant murine relatives.

Only humans, though, got examined verbally, as well as hair-pullingly. The scientists pulled hairs on the test subjects' "forearm, hand, and foot regions", then asked each hairy-armed, hairy-handed or hairy-footed person to indicate, via a questionnaire, whether the sensation was "throbbing", "shooting", "stabbing", "hot-burning", "aching", "tender" or whatever. Some test subjects also had some head hairs pulled.

Hurts are not all equal. The study says that the amount of force required to produce a particular level of pain "was many times lower for hair pull compared to pinprick stimulation".

Twisteddoodles *for New Scientist*


ANATOMY OF A TASK
@ twisteddoodles
"TASK NUCLEUS"
THE HEART OF THE MATTER
TASK
"DISTRACTABLES"
ALWAYS PRESENT. NEGATIVELY IMPACT TASK MANAGEMENT*
LARGE TASKS MAY BE COMPRISED OF LOTS OF SMALLER TASKS
* THIS CARTOON IS A DISTRACTABLE

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Honestly?

If you want to know the truth about dishonesty, good luck to you. That seems the underlying message from František Bartoš at the University of Amsterdam.

His study called "The untrustworthy evidence in dishonesty research" looks at lots of evidence. Then it heaves what appears to be a sigh: "In conclusion, caution is advised when relying on or applying the existing literature on dishonesty."

Recent years have seen a stream of academic papers about how often people lie or cheat and under what kinds of circumstances.

Some of those papers go further, offering certain tricks that can induce people to behave more honestly. One dishonesty-research project asked people to – just before doing a task on which they might feel tempted to cheat – write down the biblical Ten Commandments.

Bartoš tore into the statistics described in 99 published dishonesty-research papers – papers that other researchers have identified as being worth an extra, gimlet-eyed look.

He reports that many of those papers include numbers that are suspiciously low or high, or "contain results that are 'too-good-to-be-true'".

Bartoš does note that his own research, of course, could be wrong. And he writes that "there is reasonable hope" that the general situation is improving. Why? Because, recently, more people have been scrutinising the studies they read, rather than just assuming that everything is done both carefully and honestly.

Self-crumbling satellite

Almost no one wants to have a satellite fall from its decayed orbit, plummet down, down, down and bonk them. That's why a team of researchers has been playing with ways to make a self-crumbling satellite – building it partially of material that will automatically degrade as the thing plunges into the atmosphere, rendering the big solid object into little bits that burn to near-nothingness.

In glorious techno-lingo, the scientists call their approach "the use of thermites to aid spacecraft demise during re-entry". They reported their progress at a conference in Orlando, Florida, under the heading "Thermite-for-demise (T4D): From material selection to test campaign".

Some juicy detail: "The charges are expected to ignite spontaneously during the re-entry phase, supplying additional heat to components critical for the on-ground casualty risk."

Progress in any engineering adventure tends to come in clumps, each with a new little or big puzzle begging to be solved. Most recently, the team managed to "explain the reasons of the unexpected pressure build-up observed during the tests involving a fraction of activated thermite".

If reliable, the basic satellite-self-destruction-and-scattering technique will give a new, more widely dispersed metaphorical meaning to Henry Wadsworth Longfellow's poetic words, "I shot an arrow into the air / It fell to earth, I knew not where".

Dangerous coconuts

Two further additions to Feedback's collection of research studies with titles that are useful either for starting or stopping conversations.

First up, "Injuries due to falling coconuts" dropped into an issue of *The Journal of Trauma* in 1984. And then "Colonoscopy in the sitting position: Lessons learned from self-colonoscopy by using a small-caliber, variable-stiffness colonoscope" was inserted into the journal *Gastrointestinal Endoscopy* in 2006.

If you find an equally striking example, please send it (with citation details) to feedback@newscientist.com. ▮

Marc Abrahams

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